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MASSACHUSETTS COASTAL COMMERCIAL LOBSTER TRAP SAMPLING PROGRAM

MAY-NOVEMBER, 1981

Bruce T. Estrella

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Division of Marine Fisheries

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LOBSTER TRAP SAMPLING PROGRAM

MAY-NOVEMBER, 1981

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February 18, 1983

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ABSTRACT

A long-term American lobster (Homarus americanus) catch/effort and biological monitoring program was initiated in Massachusetts coastal waters in 1981. With the aid of cooperating commercial lobstermen, a total of 12,392 lobster were sampled from 5,735 trap hauls. Sampling regions were chosen for coverage of major lobstering regions of the state. Statewide catch per trap haul per set-over-day in number of lobster was 0.689 for all sizes and 0.215 for legal lobster. Catch rates were highest in the Beverly-Salem region and lowest in the outer Cape Cod region. Catch per unit effort of wire traps was significantly greater than wooden traps, with flounder yielding significantly greater catches than other baits. Lobster averaged smallest in the Buzzards Bay region, 77.6 mm, and largest in the outer Cape Cod region, 94.7 mm. Females generally outnumbered and averaged significantly smaller than males. Exploitation rates remain very high, E = 0.88 to 0.96, with the exception of the outer Cape Cod region, E = 0.45. A north-south gradient was apparent in the percent of legal females and sublegal females ovigerous, with highest incidence occurring in Buzzards Bay. The percent of females ovigerous was significantly higher for lobster $\geq$ 81 mm. Tentative estimates of size at 100% maturity are 80-85 mm in Buzzards Bay, 90-94 mm in Cape Cod Bay, and 100-104 mm in the outer Cape Cod region. Buzzards Bay exhibited the highest percentage of new-shelled lobster indicating a faster growth rate than other regions. The statewide cull rate was 11.3%, ranging from 5.6% in outer Cape Cod to 14.6% in Buzzards Bay; data indicate a relationship with fishing pressure. Incidence of shell disease and trap mortality was $< 1\%$.

LIST OF TABLES

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INTRODUCTION

The commercial lobster fishery is the most economically important single-species fishery in Massachusetts coastal waters. For many years this fishery has been monitored by the Massachusetts Division of Marine Fisheries Commercial Fisheries Statistics Project. Selected lobster fishery statistics are compiled from catch reports filed annually by lobster license holders. However, coincident with the inception of the State-Federal Lobster Management Program, and ultimately the American Lobster Fishery Management Plan (FMP), the need for a comprehensive, coastwide, organized American lobster management effort was realized. According to the precepts of the FMP, a long-term statewide monitoring program which would yield biological as well as catch per unit effort data was devised and initiated in Massachusetts in May, 1981. The FMP "left the specifics of the data reporting system to the various licensing agencies," consequently we adopted a sea sampling survey design by which both catch per unit effort and biological data could be collected temporally and areally with sufficient precision for stock assessments. The objective was to create the capability to assess variations in population parameters due to environmental and/or fishing pressure, or the effects of regulatory changes.

This program has been designed under the premise of regularly surveying the major lobstering regions of the state. Manpower constraints have influenced the design and scope of sampling and, in some cases, precluded monthly sampling effort. Nevertheless, due to large sample sizes and the manifestation of trends supported by previous sampling efforts, it is felt that the quality of this comprehensive effort has not been significantly affected.

The following report summarizes the baseline data collected during the 1981 statewide commercial lobster trap sampling program in Massachusetts coastal waters.

STUDY AREA

The study area is primarily defined by the Massachusetts territorial sea except where lobstering activities of cooperating commercial lobstermen exceeded territorial boundaries (Figure 1). Territorial waters total 5322 sq km (2055 sq n mi) of which approximately 20 percent was sampled during 1981. Five sampling regions, Cape Ann, Beverly-Salem, Cape Cod Bay, outer Cape Cod, and Buzzards Bay, were chosen with consideration for coverage of the major lobstering regions of the state within resources available. For convenience, these regions are depicted as generalized areas (hatchmarked) wherein lobster gear sampled may be discontinuously distributed.

SAMPLING PROCEDURE

Coverage of coastal waters was accomplished by monitoring catches during the normal lobstering operations of volunteer commercial lobstermen in each

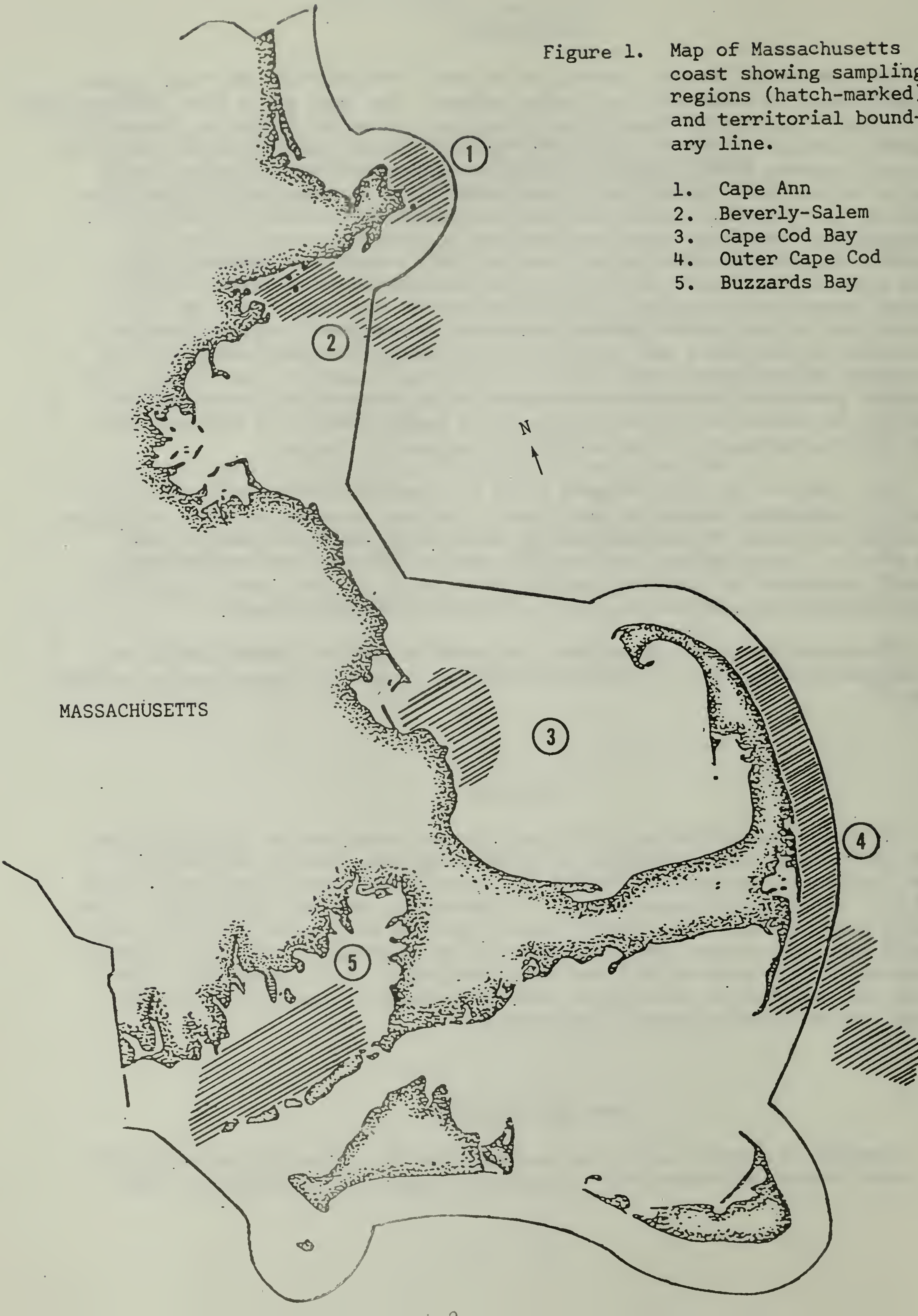


Figure 1. Map of Massachusetts coast showing sampling regions (hatch-marked) and territorial boundary line.

1. Cape Ann
2. Beverly-Salem
3. Cape Cod Bay
4. Outer Cape Cod
5. Buzzards Bay

designated region. Pot-sampling trips were day trips, conducted a minimum of once per month per region (except where manpower limitations precluded effort) during the major lobstering season, May through November.

Utilizing portable cassette tape recorders, sea samplers recorded carapace length to the nearest mm and to the nearest 0.1 mm between 80.5 and 81.0 mm; sex; and condition, including the degree of shell hardness, culls and other shell damage, external pathology, mortality, and presence of extruded ova on females (ovigerous). Catch in number of lobster, number of trap hauls, set-over-days, trap and bait type were also recorded.

ANALYTICAL PROCEDURE

Data were computer coded and keypunched for analysis on the Woods Hole Oceanographic Institution's Digital Equipment Corporation VAX-11 computer system. A computer auditing process was used to uncover keypunch and recording errors and a software analysis package was developed using SPSS and BMD statistical subprograms.

Tests for normality of variables were conducted using normal probability plots. The expected normal values for relative ranks of observations were estimated by:

$$\Phi^{-1}[3j-1)/(3N+1)]$$

where,

j = rank order of observation
N = total frequency.

Crosstabulations of variables were tested for homogeneity of distribution using the Kolmogorov-Smirnov two-sample test which is sensitive to differences in median, dispersion, and skewness. Kruskal-Wallis one-way analysis of variance and Duncan's multiple range test were used in trend analyses to determine whether sample sets tested were from the same population.

Exploitation rates equal the proportion of lobster within the recruit molt group, 81-92 mm.

Unless specified otherwise, the terms "legal" or "legal sized" lobster include all lobster in the length category $\geq$ 81 mm. The marketable segment of this category, which excludes ovigerous females, is analyzed separately.

Since the thrust of current management methodology stresses uniform coastwide regulations, all data are grouped for a statewide analysis. However, the uniqueness of the Massachusetts coastline, its role in providing a temperature barrier which profoundly affects many marine species, American lobster notwithstanding, and the influence of offshore lobster stocks on the inshore population mandate a regional data treatment as well. Comparability of reported regional differences may be slightly influenced by irregular monthly sampling.

RESULTS AND DISCUSSION

During the period of May through November, 1981, thirty-six trips were made aboard commercial lobster vessels in Massachusetts coastal waters. A total of 12,392 lobster were sampled from 5,735 trap hauls.

Catch Per Unit Effort

Catch per unit effort (CPUE) in the lobster fishery has been traditionally measured by catch per trap haul (CTHAUL). However, this index of abundance has been shown to be unreliable due to its insensitivity to seasonal changes in catchability (Thomas 1973). The weighting of CTHAUL with trap immersion time (soak time) is currently regarded as the preferred technique for measuring stock density.

The relationship between CTHAUL and soak time has been shown to be asymptotic while catch per trap haul per set-over-day (CTHSOD) decreases with increasing soak time (Fogarty and Borden 1980). Using pooled data from the present study, CTHAUL and CTHSOD were calculated and plotted against set-over-days (Figure 2). Though CTHSOD does decline with soak time, an asymptotic curve is not discernible for CTHAUL. This incongruity between studies is instructive because it is apparently due to pooling complementary data sets of discontinuous soak times with regional and seasonal catch rate variability. This factor alone can preclude the use of CTHAUL indices in pot-sampling surveys. An analysis of CTHAUL and set-over-days by month and region for available continuous soak time sets indicates an asymptotic relationship does in fact exist.

The statewide average CTHSOD in number of lobster for all sizes was 0.689. For lobster $\geq$ 81 mm (legal length category) CTHSOD was 0.227 and for those < 81 mm (sublegal length category) CTHSOD was 0.462. Excluding berried females, the legal CTHSOD was 0.215 (Table 1).

By region, for combined length categories, CTHSOD was greatest in Beverly-Salem at 1.024 followed by Buzzards Bay, 0.917; Cape Cod Bay, 0.872; Cape Ann, 0.225 and outer Cape Cod 0.157. Regional indices for legal sized lobster indicated Beverly-Salem to be highest at 0.316, followed by Cape Cod Bay, 0.268; Buzzards Bay, 0.204; Cape Ann, 0.169; and outer Cape Cod, 0.129. The legal index trend, less berried females, was similar. For sublegals, CTHSOD was greatest in Buzzards Bay at 0.713, followed by Beverly-Salem, 0.707; Cape Cod Bay, 0.604; Cape Ann, 0.056; and outer Cape Cod, 0.028 (Table 1).

By month, the statewide CTHSOD averages for all lobster, legals and sublegals, are listed in Table 2. The general trend is marked by a decline in catch in June followed by elevated catches through October, then a return to spring levels in November. The same trend has been exhibited in Maine's trap fishery (Thomas 1973) and is tentatively supported by Buzzards Bay, Cape Cod Bay, and outer Cape Cod data (Tables 3 and 4). Indications are that the Buzzards Bay trend may occur one month earlier than other regions, and is

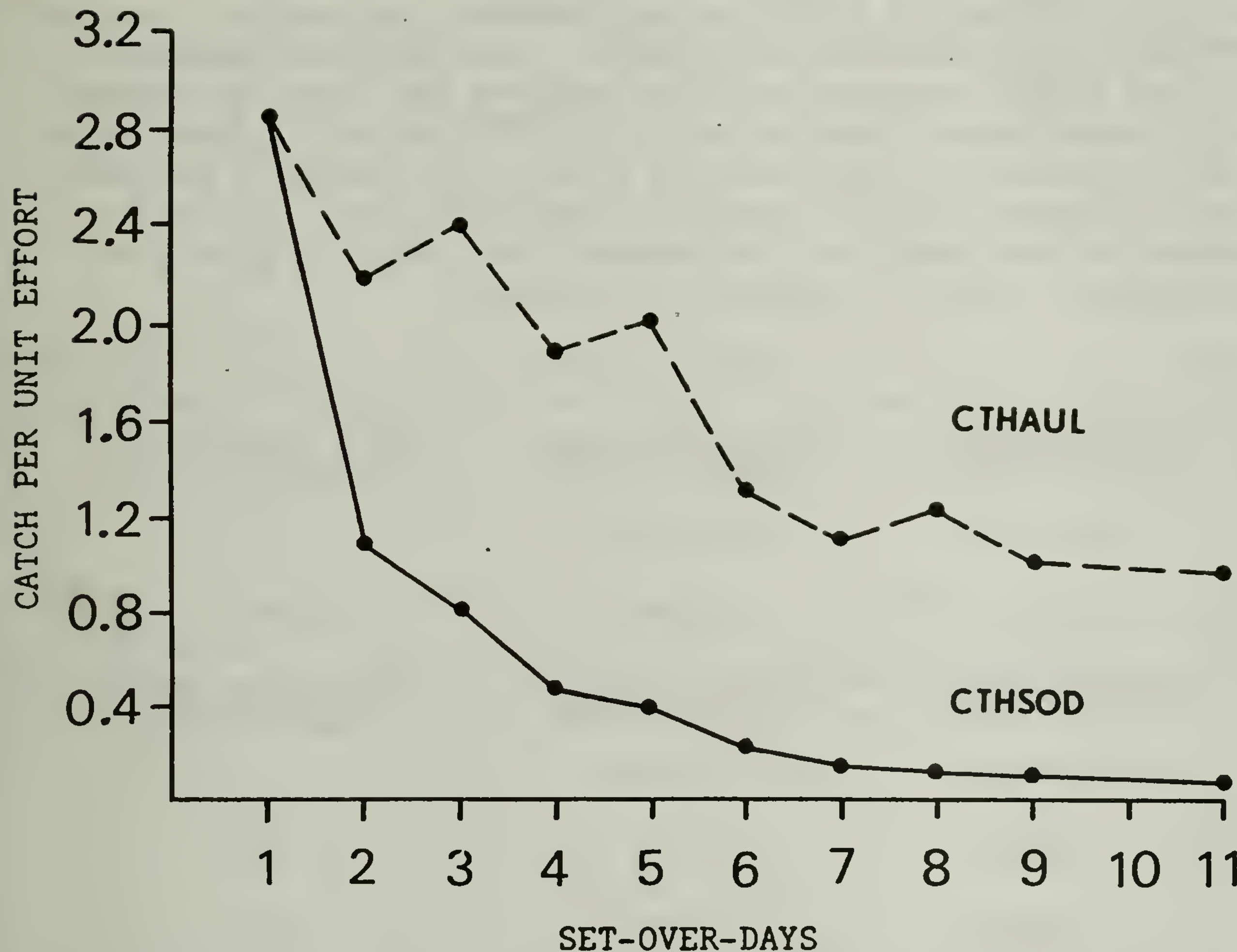


Figure 2. Relationship between catch per unit effort in number of American lobster and set-over-days, regions combined, 1981.

probably due to warmer water temperatures (Phillips et al. 1980). The early season decrease is characteristic of the onset of the molt period and a concomitant unavailability of legal sized lobster. Subsequent catch elevations may be due to the recruit molt class or the influence of seasonal offshore stock mixing (Morrissey 1971). Reduced availability in the fall may again be subject to the influence of several variables among which are fishing effort, seasonal change in activity level relative to optimal temperature (McLeese and Wilder 1958), fading of offshore stock influence, or the onset of the autumn molt period.

Using a conversion factor of 1.198 lbs per lobster, calculated from 1980 experimental commercial catch sampling,to convert legal CPUE in numbers to pounds, the CTHAUL and CTHSOD calculations for Cape Cod Bay from the present study approximately double those computed by Fair (1976 and 1977) from intercept interviews with commercial lobstermen and actual catch weights for basically the same region (Gurnet Point to Cape Cod Canal) in 1975. It is encouraging that statewide landings (lbs) calculated from catch reports also increased by approximately two-fold over the same period:

	Fair (1976)	Present Study	Fold Increase
	July 1975	July 1981	
CTHSOD	0.17	0.316	1.86
	Fair (1977)	Present Study	Fold Increase
	1975 season	1981 season	
CTHAUL	0.4553	0.775	1.70
CTHSOD	0.1921	0.307	1.59
Total landings	4,907,890	9,186,219	1.87

The statewide sublegal to legal ratio was 2.03. By region, Buzzards Bay ranked highest with a ratio of 3.50, followed by Cape Cod Bay, 2.25; Beverly-Salem, 2.24; Cape Ann, 0.33; and outer Cape Cod, 0.22.

CTHSOD of sublegals must be interpreted cautiously due to differences among lobstermen in adherence to the escape vent regulation. Some utilize standard commercially produced escape vents, and others separate trap lathes. Fogarty and Borden (1980) found the former method was more efficient in allowing escapement. A seemingly logical explanation may be that if lathe spacing is accomplished during haul-out when traps are dry, subsequent immersion and wood swelling will constrict the vent opening. The relative thickness of the two vent types may be another factor for consideration. Krouse (1978) found no significant difference in catch with vent orientation. However, escape vents have been demonstrated to enhance legal lobster catch

(Fair and Estrella 1976; Fogarty and Borden 1980; Krouse 1978).

Catch may also vary with gear and bait type employed. All data were pooled to test effects of trap and bait type on catch per unit effort. Overall, CTHAUL and CTHSOD indices for all sized lobster were significantly larger with wire traps ($P = 0.002$ and $P = 0.015$, respectively):

	Wire	Wood
CTHAUL	2.948	2.133
CTHSOD	1.037	0.862

In additional analyses, wire traps outfished wood traps in all cases (where sample sizes were adequate for testing) for a given bait type, region, and month. CPUE indices were also significantly different among bait types ($P < 0.001$). Flounder ranked first and herring second in total lobster caught.

The statewide legal CTHSOD in number of lobster, excluding ovigerous females, was 0.215. Using a conversion factor of 1.18 lbs per lobster derived from lobstermen catch reports tallied by the Commercial Fisheries Statistics Project, the 1981 CTHSOD in lbs was calculated as 0.254.

Carapace Length

The statewide average carapace length for all lobster was 80.4 mm. Legal sized lobster ($\geq$ 81 mm) averaged 88.9 mm and sublegals ($<$ 81 mm) averaged 76.2 mm (Table 5, Figure 3). The average male, at 80.8 mm, was significantly larger than the average female, 80.1 mm ($P < 0.001$, Table 6).

By region, outer Cape Cod averaged largest at 94.7 mm followed by Cape Ann, 86.2 mm; Cape Cod Bay, 80.0 mm; Beverly-Salem, 78.7 mm; and Buzzards Bay, 77.6 mm). All regional means were significantly different ($P < 0.001$, Table 5, Figures 4-8). For all regions except outer Cape Cod, males averaged larger than females (Table 6). The average legal length was greatest in outer Cape Cod at 98.8 mm followed by Cape Ann, 88.9 mm; Cape Cod Bay, 87.7 mm; Beverly-Salem, 87.5 mm; and Buzzards Bay, 84.8 mm. Average sublegal length was 78.0 mm for Cape Ann, followed by Cape Cod Bay, 76.6 mm; outer Cape Cod, 75.9 mm; Buzzards Bay, 75.6 mm; and Beverly-Salem, 74.7 mm (Table 5).

Average legal size calculated five years earlier by Fair and Estrella (1976) for vented traps in Beverly-Salem, Cape Cod Bay (Plymouth) and Buzzards Bay are similar to 1981 values:

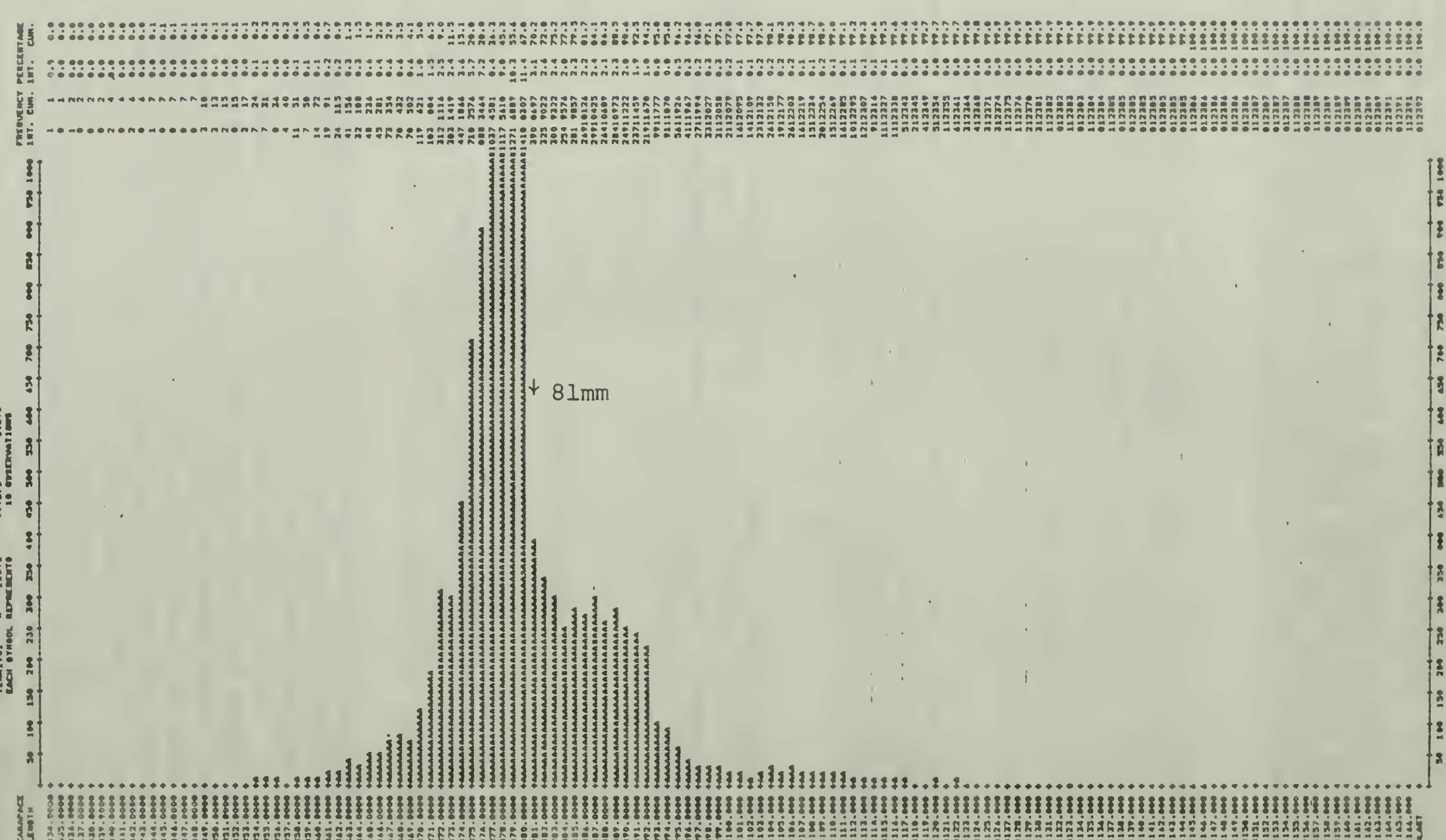
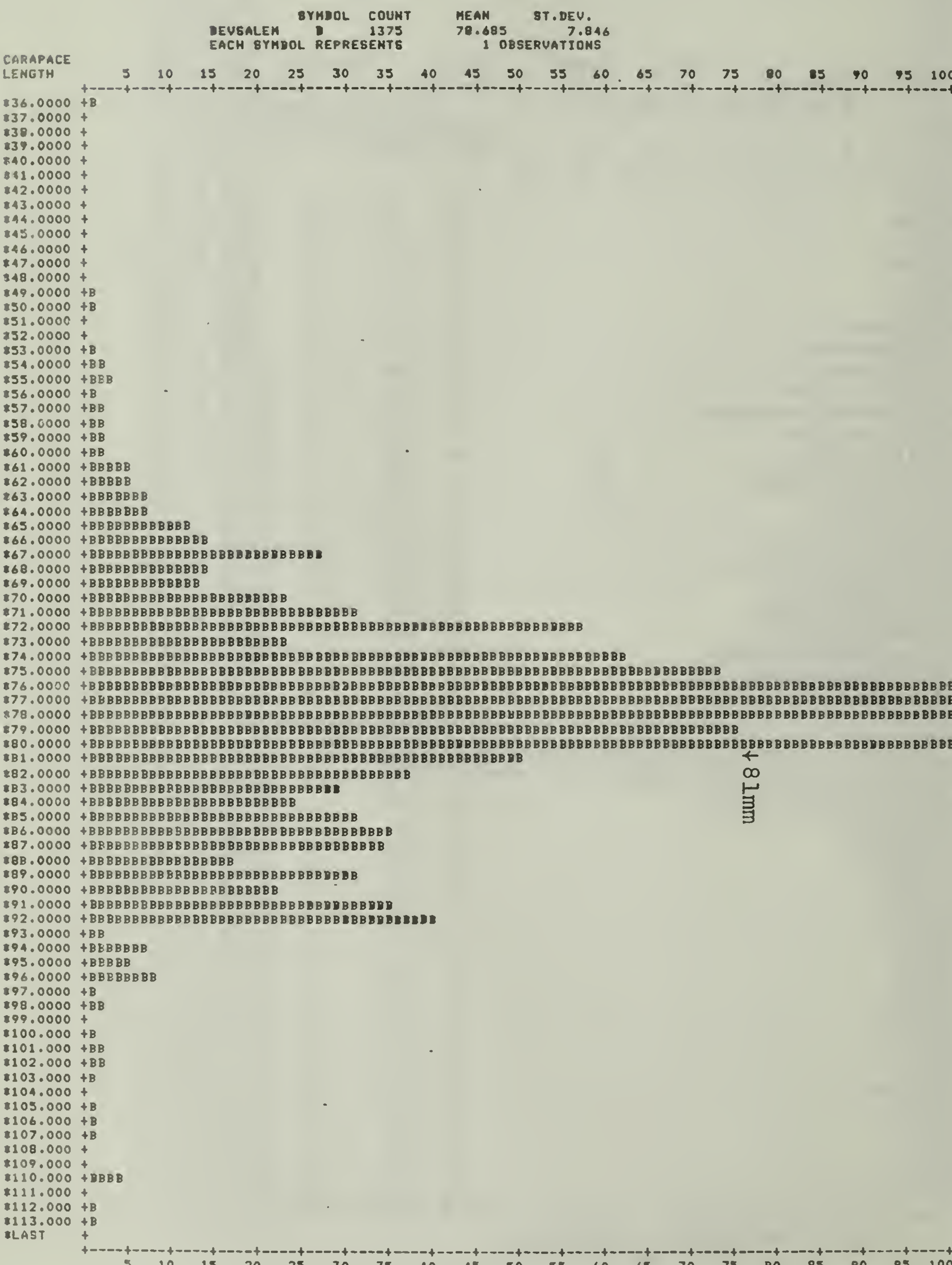


Figure 3. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for all American lobster sampled during 1981.

Figure 4. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for American lobster sampled from Cape Ann, 1981.

```
                               SYMBOL   COUNT      MEAN      ST.DEV.
                     CAPEANN     A        200      86.170        7.423
                     EACH SYMBOL REPRESENTS           1 OBSERVATIONS
CARAPACE                                           FREQUENCY PERCENTAGE
LENGTH                 5    10    15    20    25    30   INT. CUM.  INT.  CUM.
           +----+----+----+----+----+----+
*70.0000 +A                                          1    1   0.5    0.5
*71.0000 +A                                          1    2   0.5    1.0
*72.0000 +                                           0    2   0.0    1.0
*73.0000 +AA                                         2    4   1.0    2.0
*74.0000 +                                           0    4   0.0    2.0
*75.0000 +                                           0    4   0.0    2.0
*76.0000 +AAAAA                                      5    9   2.5    4.5
*77.0000 +AAAAAAAA                                   8   17   4.0    8.5
*78.0000 +AAAAAAA                                    7   24   3.5   12.0
*79.0000 +AAAAAAAAAA                                10   34   5.0   17.0
*80.0000 +AAAAAAAAAAAAAAAA                          16   50   8.0   25.0
*81.0000 +AAAAAAAAA                    ←             9   59   4.5   29.5
*82.0000 +AAAAAAAAA                  81mm            9   68   4.5   34.0
*83.0000 +AAAAAAAAAAAA                              12   80   6.0   40.0
*84.0000 +AAAAAAA                                    7   87   3.5   43.5
*85.0000 +AAAAAAA                                    7   94   3.5   47.0
*86.0000 +AAAAAAAAAAAA                              12  106   6.0   53.0
*87.0000 +AAAAAAAAAAAAA                             13  119   6.5   59.5
*88.0000 +AAAAAAAAAA                                10  129   5.0   64.5
*89.0000 +AAAAAAAAAAA                               11  140   5.5   70.0
*90.0000 +AAAAAAAAA                                  9  149   4.5   74.5
*91.0000 +AAAAAAAAAAAAAAA                           15  164   7.5   82.0
*92.0000 +AAAAAAAAAAAAAAAAA                         17  181   8.5   90.5
*93.0000 +AAAAA                                      5  186   2.5   93.0
*94.0000 +A                                          1  187   0.5   93.5
*95.0000 +                                           0  187   0.0   93.5
*96.0000 +A                                          1  188   0.5   94.0
*97.0000 +A                                          1  189   0.5   94.5
*98.0000 +                                           0  189   0.0   94.5
*99.0000 +AA                                         2  191   1.0   95.5
*100.000 +A                                          1  192   0.5   96.0
*101.000 +                                           0  192   0.0   96.0
*102.000 +A                                          1  193   0.5   96.5
*103.000 +                                           0  193   0.0   96.5
*104.000 +                                           0  193   0.0   96.5
*105.000 +                                           0  193   0.0   96.5
*106.000 +                                           0  193   0.0   96.5
*107.000 +A                                          1  194   0.5   97.0
*108.000 +A                                          1  195   0.5   97.5
*109.000 +                                           0  195   0.0   97.5
*110.000 +                                           0  195   0.0   97.5
*111.000 +AAA                                        3  198   1.5   99.0
*112.000 +A                                          1  199   0.5   99.5
*113.000 +                                           0  199   0.0   99.5
*114.000 +                                           0  199   0.0   99.5
*115.000 +                                           0  199   0.0   99.5
*116.000 +A                                          1  200   0.5  100.0
*LAST    +                                           0  200   0.0  100.0
           +----+----+----+----+----+----+
               5    10    15    20    25    30
```

Figure 5. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for American lobster sampled from Beverly-Salem, 1981.



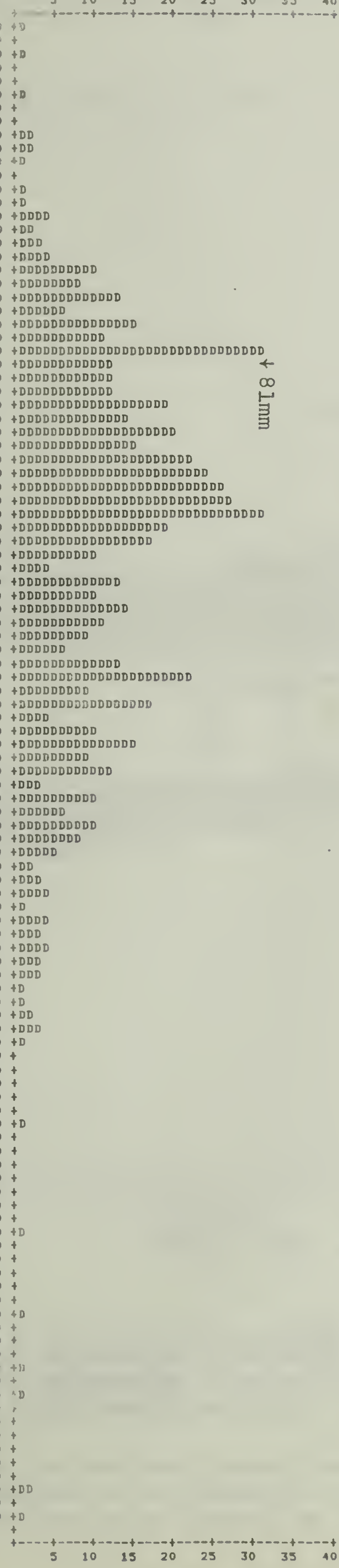
CARAPACE LENGTH	FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
*36.0000	1	1	0.1	0.1
*37.0000	0	1	0.0	0.1
*38.0000	0	1	0.0	0.1
*39.0000	0	1	0.0	0.1
*40.0000	0	1	0.0	0.1
*41.0000	0	1	0.0	0.1
*42.0000	0	1	0.0	0.1
*43.0000	0	1	0.0	0.1
*44.0000	0	1	0.0	0.1
*45.0000	0	1	0.0	0.1
*46.0000	0	1	0.0	0.1
*47.0000	0	1	0.0	0.1
*48.0000	0	1	0.0	0.1
*49.0000	1	2	0.1	0.1
*50.0000	1	3	0.1	0.2
*51.0000	0	3	0.0	0.2
*52.0000	0	3	0.0	0.2
*53.0000	1	4	0.1	0.3
*54.0000	2	6	0.1	0.4
*55.0000	3	9	0.2	0.7
*56.0000	1	10	0.1	0.7
*57.0000	2	12	0.1	0.9
*58.0000	2	14	0.1	1.0
*59.0000	2	16	0.1	1.2
*60.0000	2	18	0.1	1.3
*61.0000	5	23	0.4	1.7
*62.0000	5	28	0.4	2.0
*63.0000	7	35	0.5	2.5
*64.0000	7	42	0.5	3.1
*65.0000	12	54	0.9	3.9
*66.0000	14	68	1.0	4.9
*67.0000	27	95	2.0	6.9
*68.0000	14	109	1.0	7.9
*69.0000	13	122	0.9	8.9
*70.0000	23	145	1.7	10.5
*71.0000	31	176	2.3	12.8
*72.0000	57	233	4.1	16.9
*73.0000	23	256	1.7	18.6
*74.0000	62	318	4.5	23.1
*75.0000	73	391	5.3	28.4
*76.0000	128	519	9.3	37.7
*77.0000	123	642	8.9	46.7
*78.0000	131	773	9.5	56.2
*79.0000	75	848	5.5	61.7
*80.0000	102	950	7.4	69.1
*81.0000	50	1000	3.6	72.7
*82.0000	37	1037	2.7	75.4
*83.0000	29	1066	2.1	77.5
*84.0000	24	1090	1.7	79.3
*85.0000	31	1121	2.3	81.5
*86.0000	35	1156	2.5	84.1
*87.0000	34	1190	2.5	86.5
*88.0000	17	1207	1.2	87.8
*89.0000	31	1238	2.3	90.0
*90.0000	22	1260	1.6	91.6
*91.0000	35	1295	2.5	94.2
*92.0000	40	1335	2.9	97.1
*93.0000	2	1337	0.1	97.2
*94.0000	7	1344	0.5	97.7
*95.0000	5	1349	0.4	98.1
*96.0000	8	1357	0.6	98.7
*97.0000	1	1358	0.1	98.8
*98.0000	2	1360	0.1	98.9
*99.0000	0	1360	0.0	98.9
*100.000	1	1361	0.1	99.0
*101.000	2	1363	0.1	99.1
*102.000	2	1365	0.1	99.3
*103.000	1	1366	0.1	99.3
*104.000	0	1366	0.0	99.3
*105.000	1	1367	0.1	99.4
*106.000	1	1368	0.1	99.5
*107.000	1	1369	0.1	99.6
*108.000	0	1369	0.0	99.6
*109.000	0	1369	0.0	99.6
*110.000	4	1373	0.3	99.9
*111.000	0	1373	0.0	[illegible]
*112.000	1	1374	0.1	99.9
*113.000	1	1375	0.1	100.0
*LAST	0	1375	0.0	100.0

Figure 6. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for American lobster sampled from Cape Cod Bay, 1981.

```
                      SYMBOL  COUNT     MEAN      ST.DEV.
          CCBAY         C     8299     79.988       6.752
          EACH SYMBOL REPRESENTS         10 OBSERVATIONS
CARAPACE                                                                                              FREQUENCY PERCENTAGE
LENGTH      50  100  150  200  250  300  350  400  450  500  550  600  650  700  750  800  850  900  950 1000   INT. CUM.  INT.  CUM.
         +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
*40.0000 +                                                                                                      1    1   0.0   0.0
*41.0000 +                                                                                                      0    1   0.0   0.0
*42.0000 +                                                                                                      1    2   0.0   0.0
*43.0000 +                                                                                                      0    2   0.0   0.0
*44.0000 +                                                                                                      1    3   0.0   0.0
*45.0000 +                                                                                                      0    3   0.0   0.0
*46.0000 +                                                                                                      0    3   0.0   0.0
*47.0000 +                                                                                                      0    3   0.0   0.0
*48.0000 +                                                                                                      0    3   0.0   0.0
*49.0000 +                                                                                                      2    5   0.0   0.1
*50.0000 +                                                                                                      1    6   0.0   0.1
*51.0000 +                                                                                                      1    7   0.0   0.1
*52.0000 +                                                                                                      0    7   0.0   0.1
*53.0000 +                                                                                                      1    8   0.0   0.1
*54.0000 +                                                                                                      2   10   0.0   0.1
*55.0000 +                                                                                                      4   14   0.0   0.2
*56.0000 +                                                                                                      3   17   0.0   0.2
*57.0000 +                                                                                                      2   19   0.0   0.2
*58.0000 +C                                                                                                     5   24   0.1   0.3
*59.0000 +                                                                                                      4   28   0.0   0.3
*60.0000 +C                                                                                                    11   39   0.1   0.5
*61.0000 +C                                                                                                     6   45   0.1   0.5
*62.0000 +C                                                                                                    13   58   0.2   0.7
*63.0000 +CCC                                                                                                  27   85   0.3   1.0
*64.0000 +CC                                                                                                   18  103   0.2   1.2
*65.0000 +CC                                                                                                   23  126   0.3   1.5
*66.0000 +CC                                                                                                   18  144   0.2   1.7
*67.0000 +CCC                                                                                                  29  173   0.3   2.1
*68.0000 +CCCC                                                                                                 44  217   0.5   2.6
*69.0000 +CCCC                                                                                                 38  255   0.5   3.1
*70.0000 +CCCCCC                                                                                               57  312   0.7   3.8
*71.0000 +CCCCCCCCCCC                                                                                         106  418   1.3   5.0
*72.0000 +CCCCCCCCCCCCCCCCCC                                                                                  180  598   2.2   7.2
*73.0000 +CCCCCCCCCCCCCCCCCCCCC                                                                               209  807   2.5   9.7
*74.0000 +CCCCCCCCCCCCCCCCCCCCCCCCCCCC                                                                        279 1086   3.4  13.1
*75.0000 +CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC                                                  496 1582   6.0  19.1
*76.0000 +CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC                                           593 2175   7.1  26.2
*77.0000 +CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC                           736 2911   8.9  35.1
*78.0000 +CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC                   820 3731   9.9  45.0
*79.0000 +CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC    968 4699  11.7  56.6
*80.0000 +CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC*1046 5745  12.6  69.2
*81.0000 +CCCCCCCCCCCCCCCCCCCCCCCCC                     ← 81mm                                         247 5992   3.0  72.2
*82.0000 +CCCCCCCCCCCCCCCCCCCCC                                                                           207 6199   2.5  74.7
*83.0000 +CCCCCCCCCCCCCCCCCC                                                                              183 6382   2.2  76.9
*84.0000 +CCCCCCCCCCCCCCCC                                                                                157 6539   1.9  78.8
*85.0000 +CCCCCCCCCCCCCCCCCCCC                                                                            201 6740   2.4  81.2
*86.0000 +CCCCCCCCCCCCCCCCC                                                                               172 6912   2.1  83.3
*87.0000 +CCCCCCCCCCCCCCCCCCCC                                                                            204 7116   2.5  85.7
*88.0000 +CCCCCCCCCCCCCCCCCCC                                                                             194 7310   2.3  88.1
*89.0000 +CCCCCCCCCCCCCCCCCCCCC                                                                           207 7517   2.5  90.6
*90.0000 +CCCCCCCCCCCCCCCCC                                                                               171 7688   2.1  92.6
*91.0000 +CCCCCCCCCCCCCCC                                                                                 153 7841   1.8  94.5
*92.0000 +CCCCCCCCCCCCC                                                                                   125 7966   1.5  96.0
*93.0000 +CCCCCCC                                                                                          70 8036   0.8  96.8
*94.0000 +CCCCCC                                                                                           64 8100   0.8  97.6
*95.0000 +CCCC                                                                                             38 8138   0.5  98.1
*96.0000 +CCC                                                                                              27 8165   0.3  98.4
*97.0000 +C                                                                                                11 8176   0.1  98.5
*98.0000 +CC                                                                                               21 8197   0.3  98.8
*99.0000 +CC                                                                                               15 8212   0.2  99.0
*100.000 +C                                                                                                 8 8220   0.1  99.0
*101.000 +C                                                                                                 5 8225   0.1  99.1
*102.000 +C                                                                                                 5 8230   0.1  99.2
*103.000 +C                                                                                                 9 8239   0.1  99.3
*104.000 +                                                                                                  4 8243   0.0  99.3
*105.000 +C                                                                                                 9 8252   0.1  99.4
*106.000 +C                                                                                                 8 8260   0.1  99.5
*107.000 +C                                                                                                10 8270   0.1  99.7
*108.000 +                                                                                                  4 8274   0.0  99.7
*109.000 +C                                                                                                 5 8279   0.1  99.8
*110.000 +                                                                                                  2 8281   0.0  99.8
*111.000 +                                                                                                  1 8282   0.0  99.8
*112.000 +C                                                                                                 5 8287   0.1  99.9
*113.000 +                                                                                                  1 8288   0.0  99.9
*114.000 +                                                                                                  3 8291   0.0  99.9
*115.000 +                                                                                                  1 8292   0.0  99.9
*116.000 +                                                                                                  2 8294   0.0  99.9
*117.000 +                                                                                                  0 8294   0.0  99.9
*118.000 +                                                                                                  0 8294   0.0  99.9
*119.000 +                                                                                                  1 8295   0.0 100.0
*120.000 +                                                                                                  0 8295   0.0 100.0
*121.000 +                                                                                                  0 8295   0.0 100.0
*122.000 +                                                                                                  2 8297   0.0 100.0
*123.000 +                                                                                                  0 8297   0.0 100.0
*124.000 +                                                                                                  0 8297   0.0 100.0
*125.000 +                                                                                                  0 8297   0.0 100.0
*126.000 +                                                                                                  0 8297   0.0 100.0
*127.000 +                                                                                                  0 8297   0.0 100.0
*128.000 +                                                                                                  0 8297   0.0 100.0
*129.000 +                                                                                                  0 8297   0.0 100.0
*130.000 +                                                                                                  0 8297   0.0 100.0
*131.000 +                                                                                                  0 8297   0.0 100.0
*132.000 +                                                                                                  0 8297   0.0 100.0
*133.000 +                                                                                                  1 8298   0.0 100.0
*134.000 +                                                                                                  0 8298   0.0 100.0
*135.000 +                                                                                                  1 8299   0.0 100.0
*LAST    +                                                                                                  0 8299   0.0 100.0
         +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
            50  100  150  200  250  300  350  400  450  500  550  600  650  700  750  800  850  900  950 1000
```

SYMBOL COUNT
OUTCAPE D 660
EACH SYMBOL REPRESENTS 1 OBSERVATIONS

MEAN 94.744 ST.DEV. 15.269



CARAPACE LENGTH	FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
*36.0000	1	1	0.2	0.2
*37.0000	0	1	0.0	0.2
*38.0000	1	2	0.2	0.3
*39.0000	0	2	0.0	0.3
*60.0000	0	2	0.0	0.3
*61.0000	1	3	0.2	0.5
*62.0000	0	3	0.0	0.5
*63.0000	0	3	0.0	0.5
*64.0000	2	5	0.3	0.8
*65.0000	2	7	0.3	1.1
*66.0000	1	8	0.2	1.2
*67.0000	0	8	0.0	1.2
*68.0000	1	9	0.2	1.4
*69.0000	1	10	0.2	1.5
*70.0000	4	14	0.6	2.1
*71.0000	2	16	0.3	2.4
*72.0000	3	19	0.5	2.9
*73.0000	4	23	0.6	3.5
*74.0000	10	33	1.5	5.0
*75.0000	8	41	1.2	6.2
*76.0000	13	54	2.0	8.2
*77.0000	6	60	0.9	9.1
*78.0000	15	75	2.3	11.4
*79.0000	11	86	1.7	13.0
*80.0000	31	117	4.7	17.7
*81.0000	12	129	1.8	19.5
*82.0000	12	141	1.8	21.4
*83.0000	12	153	1.8	23.2
*84.0000	19	172	2.9	26.1
*85.0000	14	186	2.1	28.2
*86.0000	20	206	3.0	31.2
*87.0000	15	221	2.3	33.5
*88.0000	22	243	3.3	36.8
*89.0000	24	267	3.6	40.5
*90.0000	26	293	3.9	44.4
*91.0000	27	320	4.1	48.5
*92.0000	31	351	4.7	53.2
*93.0000	19	370	2.9	56.1
*94.0000	17	387	2.6	58.6
*95.0000	10	397	1.5	60.2
*96.0000	4	401	0.6	60.8
*97.0000	13	414	2.0	62.7
*98.0000	10	424	1.5	64.2
*99.0000	14	438	2.1	66.4
*100.000	11	449	1.7	68.0
*101.000	9	458	1.4	69.4
*102.000	6	464	0.9	70.3
*103.000	13	477	2.0	72.3
*104.000	22	499	3.3	75.6
*105.000	9	508	1.4	77.0
*106.000	17	525	2.6	79.5
*107.000	4	529	0.6	80.2
*108.000	10	539	1.5	81.7
*109.000	15	554	2.3	83.9
*110.000	9	563	1.4	85.3
*111.000	12	575	1.8	87.1
*112.000	3	578	0.5	87.6
*113.000	10	588	1.5	89.1
*114.000	6	594	0.9	90.0
*115.000	10	604	1.5	91.5
*116.000	8	612	1.2	92.7
*117.000	5	617	0.8	93.5
*118.000	2	619	0.3	93.8
*119.000	3	622	0.5	94.2
*120.000	4	626	0.6	94.8
*121.000	1	627	0.2	95.0
*122.000	4	631	0.6	95.6
*123.000	3	634	0.5	96.1
*124.000	4	638	0.6	96.7
*125.000	3	641	0.5	97.1
*126.000	3	644	0.5	97.6
*127.000	1	645	0.2	97.7
*128.000	1	646	0.2	97.9
*129.000	2	648	0.3	98.2
*130.000	3	651	0.5	98.6
*131.000	1	652	0.2	98.8
*132.000	0	652	0.0	98.8
*133.000	0	652	0.0	98.8
*134.000	0	652	0.0	98.8
*135.000	0	652	0.0	98.8
*136.000	0	652	0.0	98.8
*137.000	1	653	0.2	98.9
*138.000	0	653	0.0	98.9
*139.000	0	653	0.0	98.9
*140.000	0	653	0.0	98.9
*141.000	0	653	0.0	98.9
*142.000	0	653	0.0	98.9
*143.000	0	653	0.0	98.9
*144.000	0	653	0.0	98.9
*145.000	1	654	0.2	99.1
*146.000	0	654	0.0	99.1
*147.000	0	654	0.0	99.1
*148.000	0	654	0.0	99.1
*149.000	0	654	0.0	99.1
*150.000	0	654	0.0	99.1
*151.000	1	655	0.2	99.2
*152.000	0	655	0.0	99.2
*153.000	0	655	0.0	99.2
*154.000	0	655	0.0	99.2
*155.000	1	656	0.2	99.4
*156.000	0	656	0.0	99.4
*157.000	1	657	0.2	99.5
*158.000	0	657	0.0	99.5
*159.000	0	657	0.0	99.5
*160.000	0	657	0.0	99.5
*161.000	0	657	0.0	99.5
*162.000	0	657	0.0	99.5
*163.000	0	657	0.0	99.5
*164.000	2	659	0.3	99.8
*165.000	0	659	0.0	99.8
*166.000	1	660	0.2	100.0
*LAST	0	660	0.0	100.0

Figure 7. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for American lobster sampled from outer Cape Cod, 1981.

Figure 8. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for American lobster sampled fron Buzzards Bay, 1981.

```
                           SYMBOL  COUNT      MEAN      ST.DEV.
                  BUZZBAY    E      1858     77.628      5.799
                  EACH SYMBOL REPRESENTS          2 OBSERVATIONS
CARAPACE                                                                                                              FREQUENCY PERCENTAGE
LENGTH       10   20   30   40   50   60   70   80   90  100  110  120  130  140  150  160  170  180  190  200          INT. CUM.  INT.  CUM.
          +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
$34.0000 +E                                                                                                          1    1   0.1   0.1
$35.0000 +                                                                                                           0    1   0.0   0.1
$36.0000 +                                                                                                           0    1   0.0   0.1
$37.0000 +                                                                                                           0    1   0.0   0.1
$38.0000 +                                                                                                           0    1   0.0   0.1
$39.0000 +                                                                                                           0    1   0.0   0.1
$40.0000 +E                                                                                                          1    2   0.1   0.1
$41.0000 +                                                                                                           0    2   0.0   0.1
$42.0000 +E                                                                                                          1    3   0.1   0.2
$43.0000 +                                                                                                           0    3   0.0   0.2
$44.0000 +                                                                                                           0    3   0.0   0.2
$45.0000 +                                                                                                           0    3   0.0   0.2
$46.0000 +                                                                                                           0    3   0.0   0.2
$47.0000 +                                                                                                           0    3   0.0   0.2
$48.0000 +                                                                                                           0    3   0.0   0.2
$49.0000 +                                                                                                           0    3   0.0   0.2
$50.0000 +E                                                                                                          1    4   0.1   0.2
$51.0000 +E                                                                                                          1    5   0.1   0.3
$52.0000 +                                                                                                           0    5   0.0   0.3
$53.0000 +                                                                                                           0    5   0.0   0.3
$54.0000 +EE                                                                                                         3    8   0.2   0.4
$55.0000 +                                                                                                           0    8   0.0   0.4
$56.0000 +                                                                                                           0    8   0.0   0.4
$57.0000 +                                                                                                           0    8   0.0   0.4
$58.0000 +EE                                                                                                         3   11   0.2   0.6
$59.0000 +E                                                                                                          1   12   0.1   0.6
$60.0000 +E                                                                                                          1   13   0.1   0.7
$61.0000 +EEEE                                                                                                       7   20   0.4   1.1
$62.0000 +EEE                                                                                                        6   26   0.3   1.4
$63.0000 +EEEE                                                                                                       7   33   0.4   1.8
$64.0000 +EEE                                                                                                        5   38   0.3   2.0
$65.0000 +EEEEEE                                                                                                    11   49   0.6   2.6
$66.0000 +EEEEEE                                                                                                    12   61   0.6   3.3
$67.0000 +EEEEEEEEE                                                                                                 17   78   0.9   4.2
$68.0000 +EEEEEEEEEE                                                                                                19   97   1.0   5.2
$69.0000 +EEEEEEEEE                                                                                                 18  115   1.0   6.2
$70.0000 +EEEEEEEEEEEEEEEEE                                                                                         34  149   1.8   8.0
$71.0000 +EEEEEEEEEEEEEEEEEEEEEE                                                                                    43  192   2.3  10.3
$72.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE                                                                      72  264   3.9  14.2
$73.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE                                                                         65  329   3.5  17.7
$74.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE                                                          96  425   5.2  22.9
$75.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE                                      133  558   7.2  30.0
$76.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE                              149  707   8.0  38.1
$77.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE                       164  871   8.8  46.9
$78.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE                                 144 1015   7.8  54.6
$79.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE$ 207 1222  11.1  65.8
$80.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE$ 223 1445  12.0  77.8
$81.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE             <- 81mm                                                 72 1517   3.9  81.6
$82.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE                                                                            60 1577   3.2  84.9
$83.0000 +EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE                                                                          64 1641   3.4  88.3
$84.0000 +EEEEEEEEEEEEEEEEEEEEEEEE                                                                                  47 1688   2.5  90.9
$85.0000 +EEEEEEEEEEEEEE                                                                                            28 1716   1.5  92.4
$86.0000 +EEEEEEEEEEEEEEE                                                                                           30 1746   1.6  94.0
$87.0000 +EEEEEEEEEEEEEEEEE                                                                                         33 1779   1.8  95.7
$88.0000 +EEEEEEEEEEE                                                                                               21 1800   1.1  96.9
$89.0000 +EEEEEE                                                                                                    11 1811   0.6  97.5
$90.0000 +EEEEEEEEEEE                                                                                               21 1832   1.1  98.6
$91.0000 +EEEE                                                                                                       7 1839   0.4  99.0
$92.0000 +EEE                                                                                                        6 1845   0.3  99.3
$93.0000 +EE                                                                                                         3 1848   0.2  99.5
$94.0000 +EE                                                                                                         4 1852   0.2  99.7
$95.0000 +EE                                                                                                         3 1855   0.2  99.8
$96.0000 +E                                                                                                          1 1856   0.1  99.9
$97.0000 +E                                                                                                          1 1857   0.1  99.9
$98.0000 +                                                                                                           0 1857   0.0  99.9
$99.0000 +                                                                                                           0 1857   0.0  99.9
$100.000 +                                                                                                           0 1857   0.0  99.9
$101.000 +                                                                                                           0 1857   0.0  99.9
$102.000 +                                                                                                           0 1857   0.0  99.9
$103.000 +                                                                                                           0 1857   0.0  99.9
$104.000 +                                                                                                           0 1857   0.0  99.9
$105.000 +                                                                                                           0 1857   0.0  99.9
$106.000 +                                                                                                           0 1857   0.0  99.9
$107.000 +                                                                                                           0 1857   0.0  99.9
$108.000 +                                                                                                           0 1857   0.0  99.9
$109.000 +                                                                                                           0 1857   0.0  99.9
$110.000 +                                                                                                           0 1857   0.0  99.9
$111.000 +                                                                                                           0 1857   0.0  99.9
$112.000 +                                                                                                           0 1857   0.0  99.9
$113.000 +                                                                                                           0 1857   0.0  99.9
$114.000 +                                                                                                           0 1857   0.0  99.9
$115.000 +                                                                                                           0 1857   0.0  99.9
$116.000 +                                                                                                           0 1857   0.0  99.9
$117.000 +                                                                                                           0 1857   0.0  99.9
$118.000 +                                                                                                           0 1857   0.0  99.9
$119.000 +                                                                                                           0 1857   0.0  99.9
$120.000 +E                                                                                                          1 1858   0.1 100.0
$LAST    +                                                                                                           0 1858   0.0 100.0
          +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
             10   20   30   40   50   60   70   80   90  100  110  120  130  140  150  160  170  180  190  200
```

	1976	1981
Beverly-Salem	86.9	87.5
Cape Cod Bay	87.3	87.7
Buzzards Bay	85.1	84.8

These minimal changes in average length infer relatively static exploitation rates which have been reported as very high in Cape Cod Bay, E = 0.93, and Buzzards Bay, E = 0.98, with only light exploitation in the outer Cape Cod region (Fair 1979). The 1981 Buzzards Bay rate remained very high, E = 0.96, while that of Cape Cod Bay was slightly lower, E = 0.88. Outer Cape Cod exhibited a comparatively low exploitation rate, E = 0.45, which is attributed to relatively low fishing pressure and the migratory nature of that population. Cape Ann and Beverly-Salem had high exploitation rates of E = 0.89 and 0.91, respectively. It is noteworthy that Buzzards Bay, which exhibits the highest exploitation rate, also exhibits the smallest mean size (77.6 mm). Fogarty and Borden (1980) and Krouse (1973) also observed this cause and effect relationship between heavy fishing pressure and small mean size.

By month, the statewide trend in average length for all lobster indicated a drop in average length in June, followed by a rise to a peak in August, then a downward trend through October with an upswing in November ($P < 0.001$, Tables 7-9 , Figures 9-16). The June decrease may be due to fishing mortality and unavailability during ecdysis, while July and November increases may be related to recruitment from the summer and fall molts. The August peak is significantly different from all other months and may be due to the combined effects of recruitment and seasonal inshore migration of large offshore lobster. Briggs and Mushacke (1980) encountered the greatest number and widest size range of all lobster in July and August off the south shore of Long Island and classified this essentially as an offshore size distribution.

Less berried females, the average legal carapace length was 88.6 mm. Males averaged 89.0 mm and females, 88.2 mm. Cape Ann, Beverly-Salem, and Cape Cod Bay exhibited similar average lengths of 88.6 mm, 87.5 mm, and 87.5 mm, respectively. Outer Cape Cod averaged largest at 97.8 mm and Buzzards Bay smallest at 84.8 mm (Table 5).

Maturity

Percent Ovigerous

Of all females captured statewide, 5.8% were ovigerous (berried). Among legal and sublegal female size groups, 9.6% and 4.2%, respectively, were berried ($P < 0.001$, Table 10).

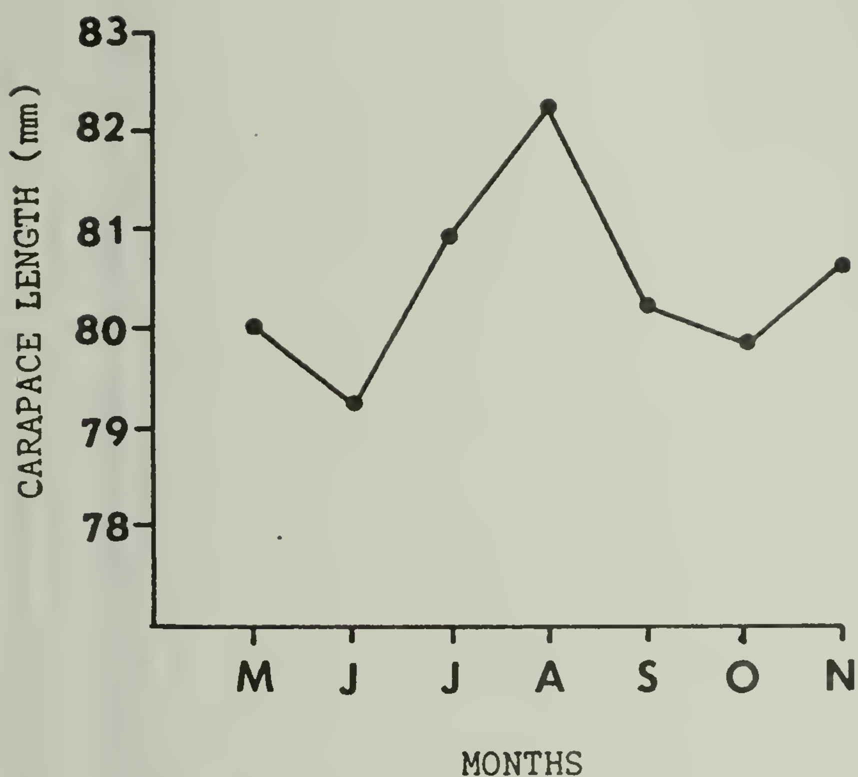


Figure 9. Relationship between average carapace length and month for all American lobster sampled, 1981.

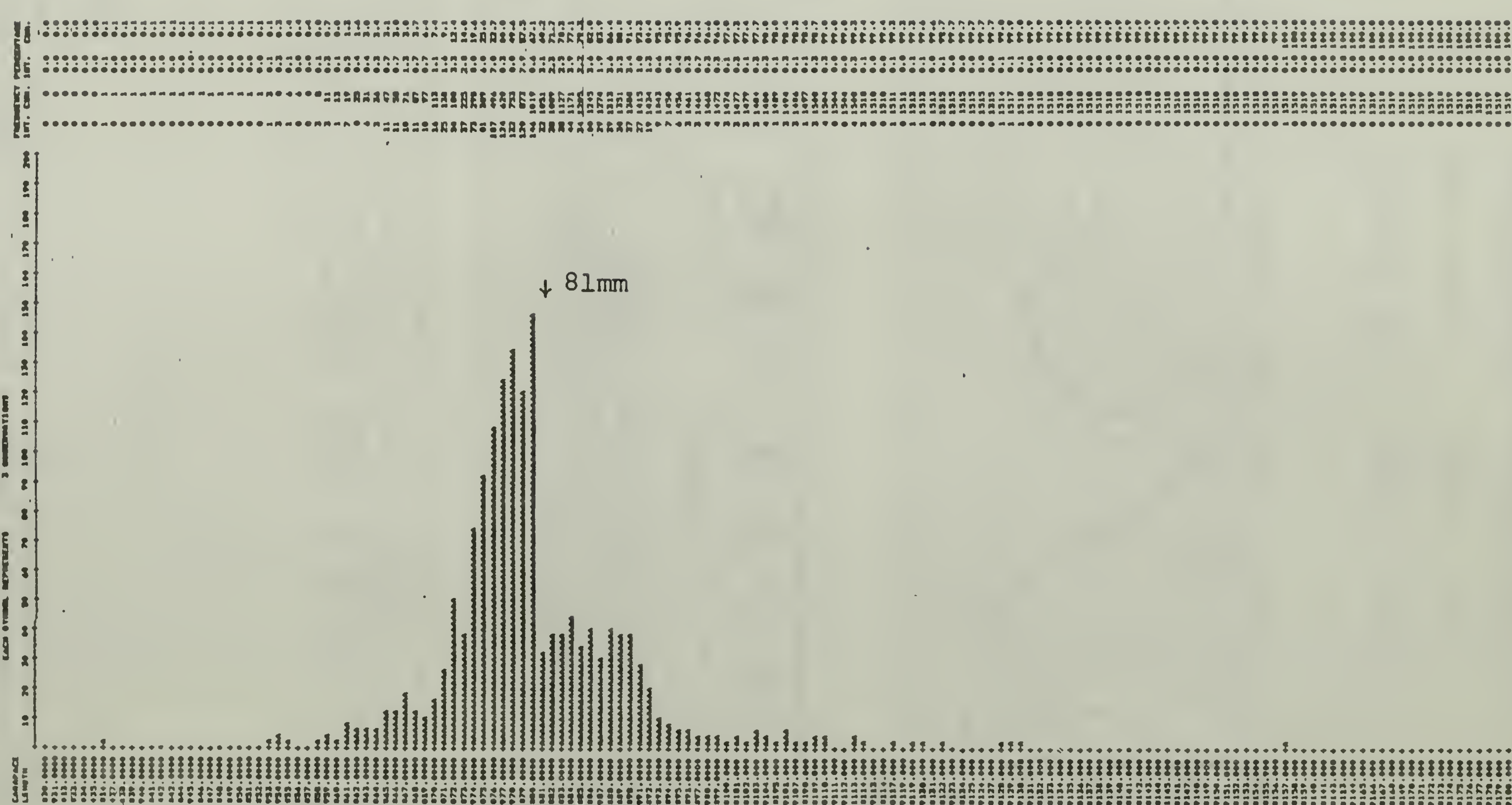


Figure 10. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for all American lobster sampled during May, 1981.

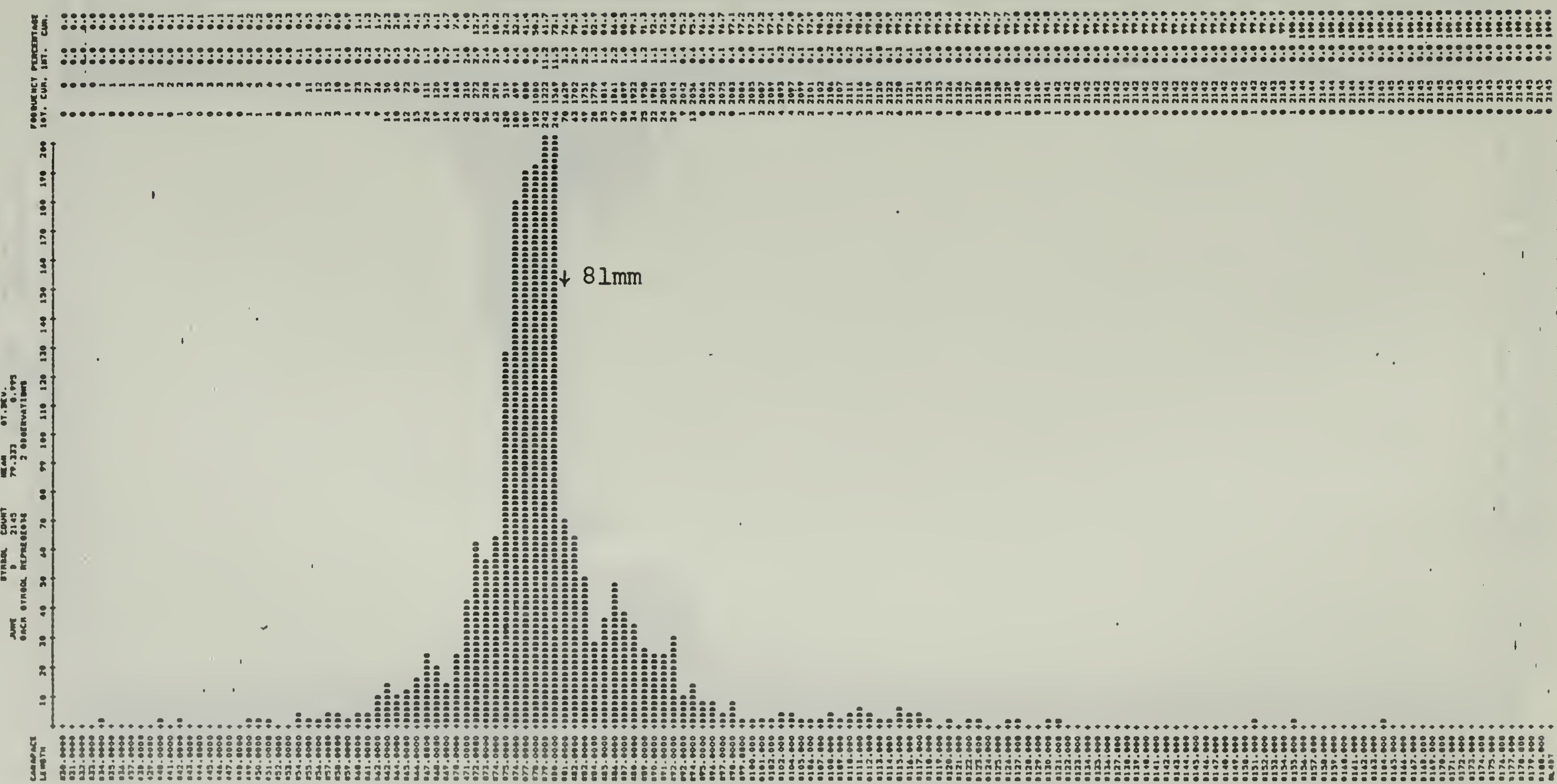


Figure 11. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for all American lobster sampled during June, 1981.

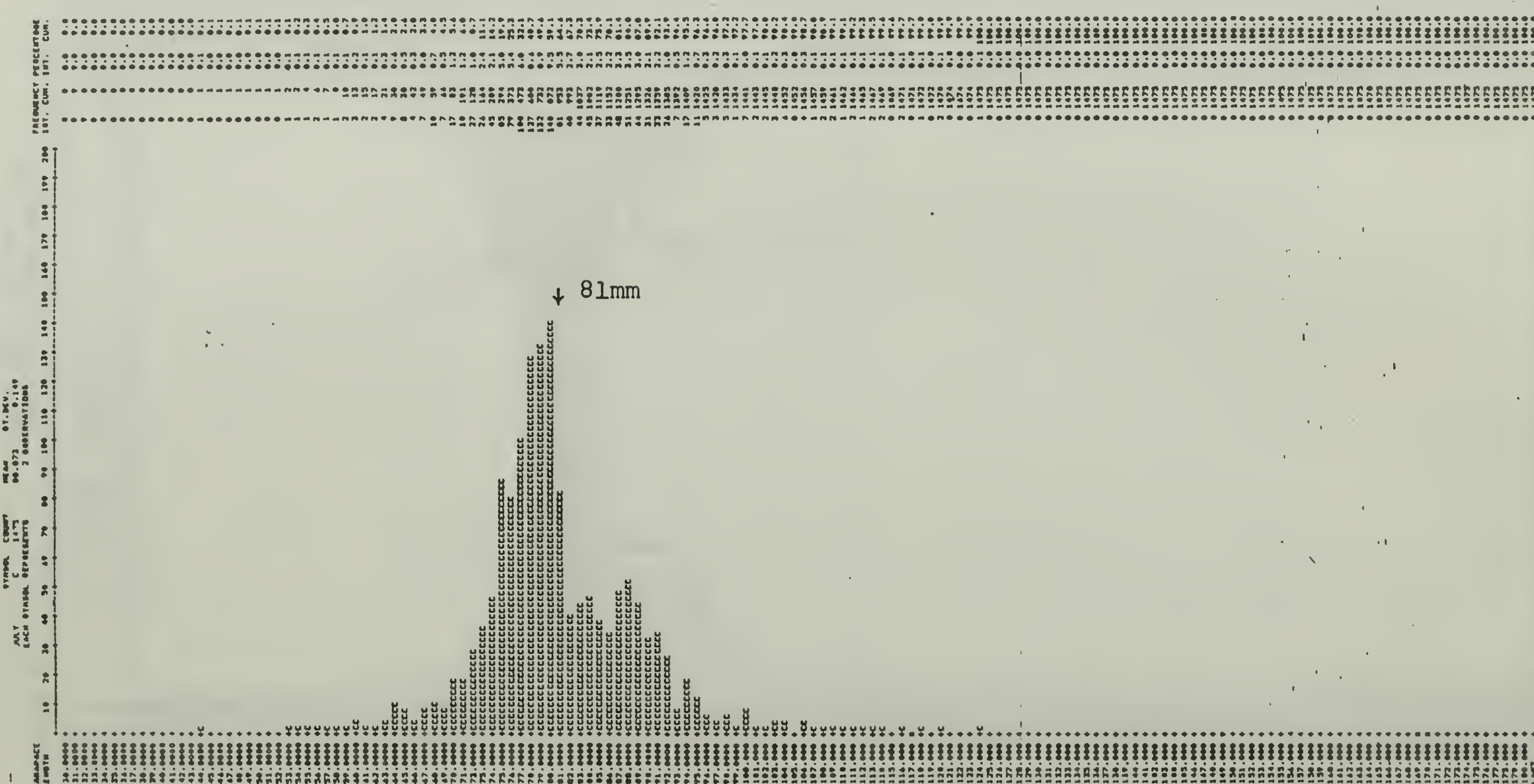


Figure 12. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for all American lobster sampled during July, 1981.

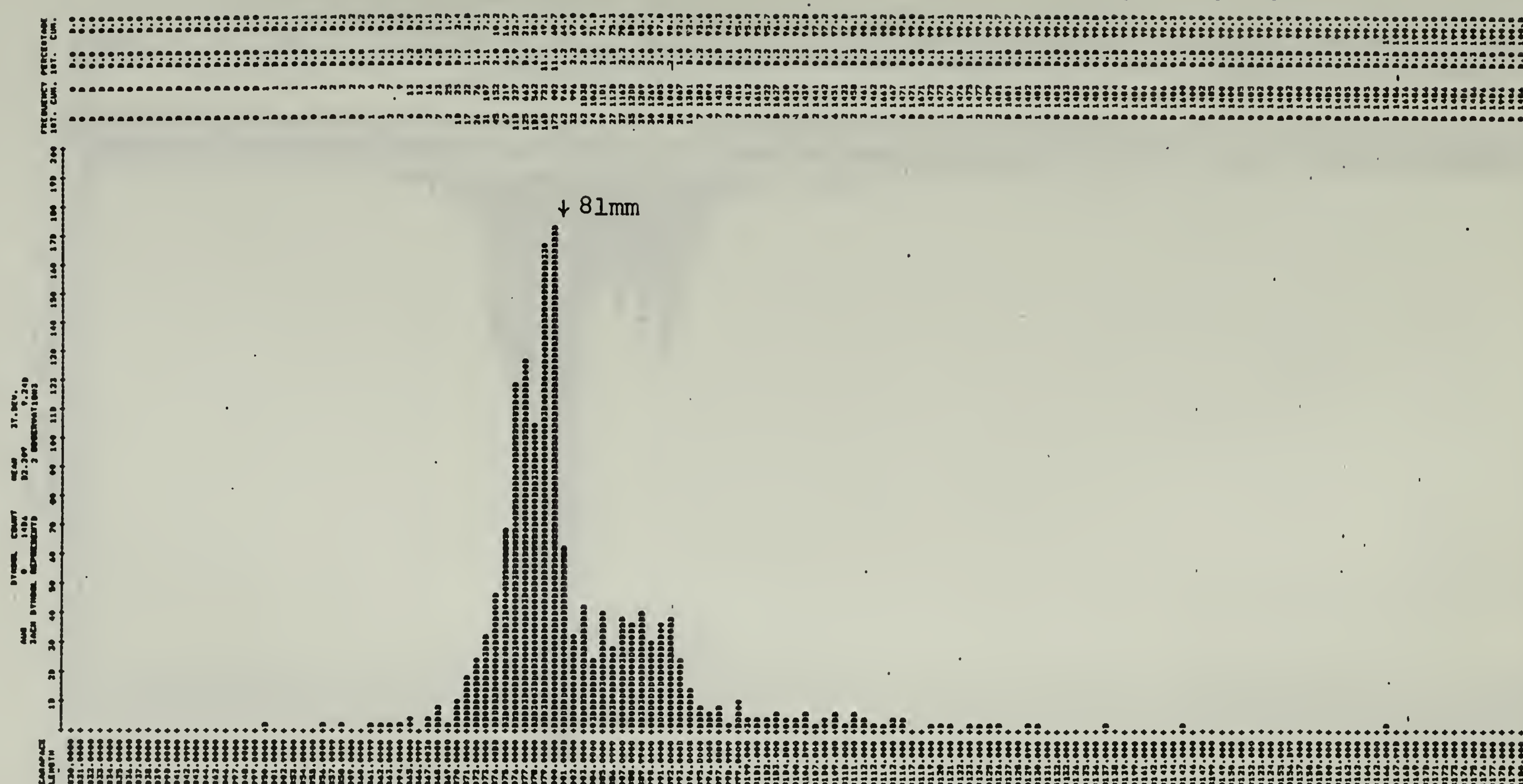


Figure 13. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for all American lobster sampled during August, 1981.

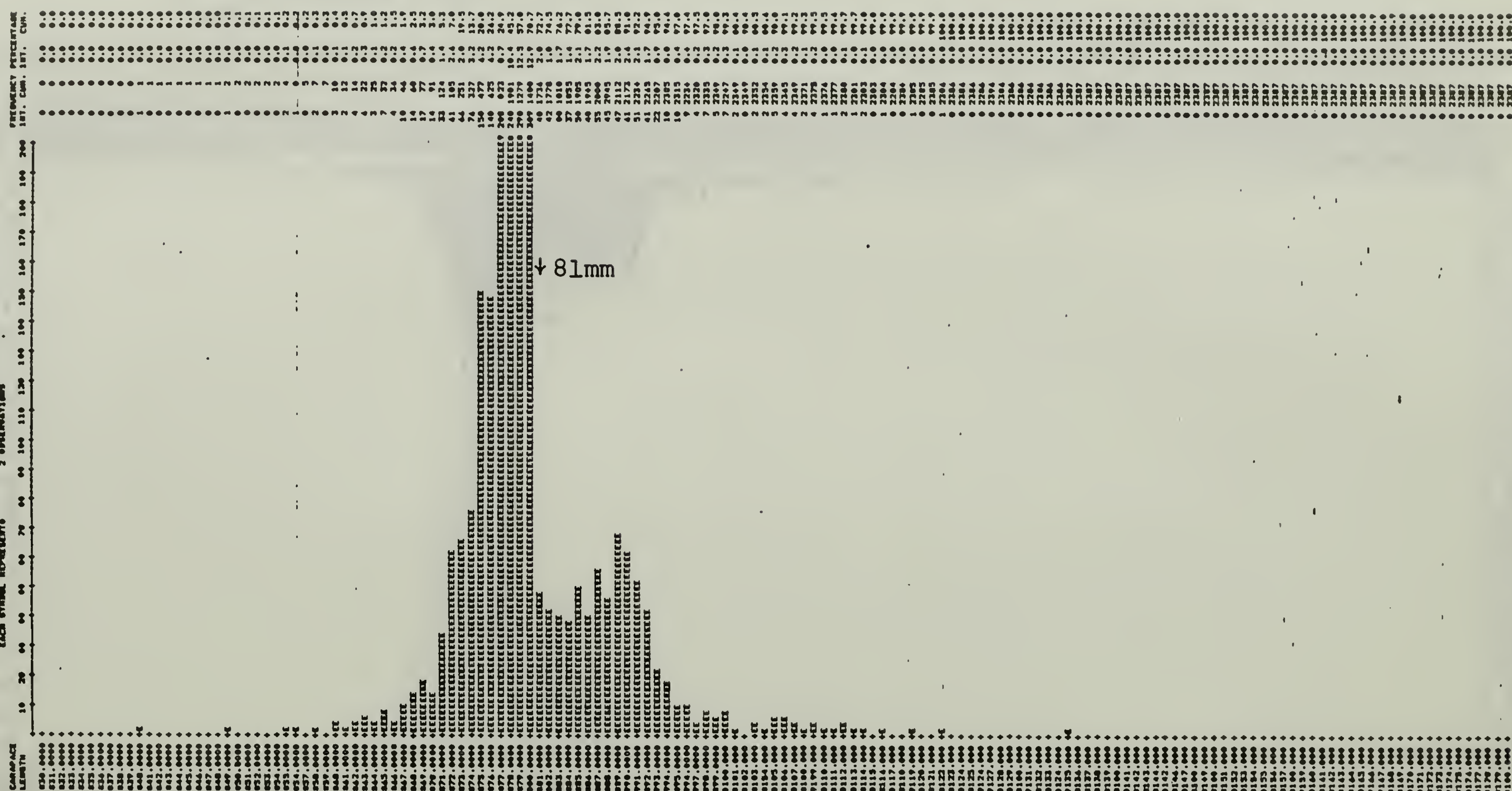


Figure 14. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for all American lobster sampled during September, 1981.

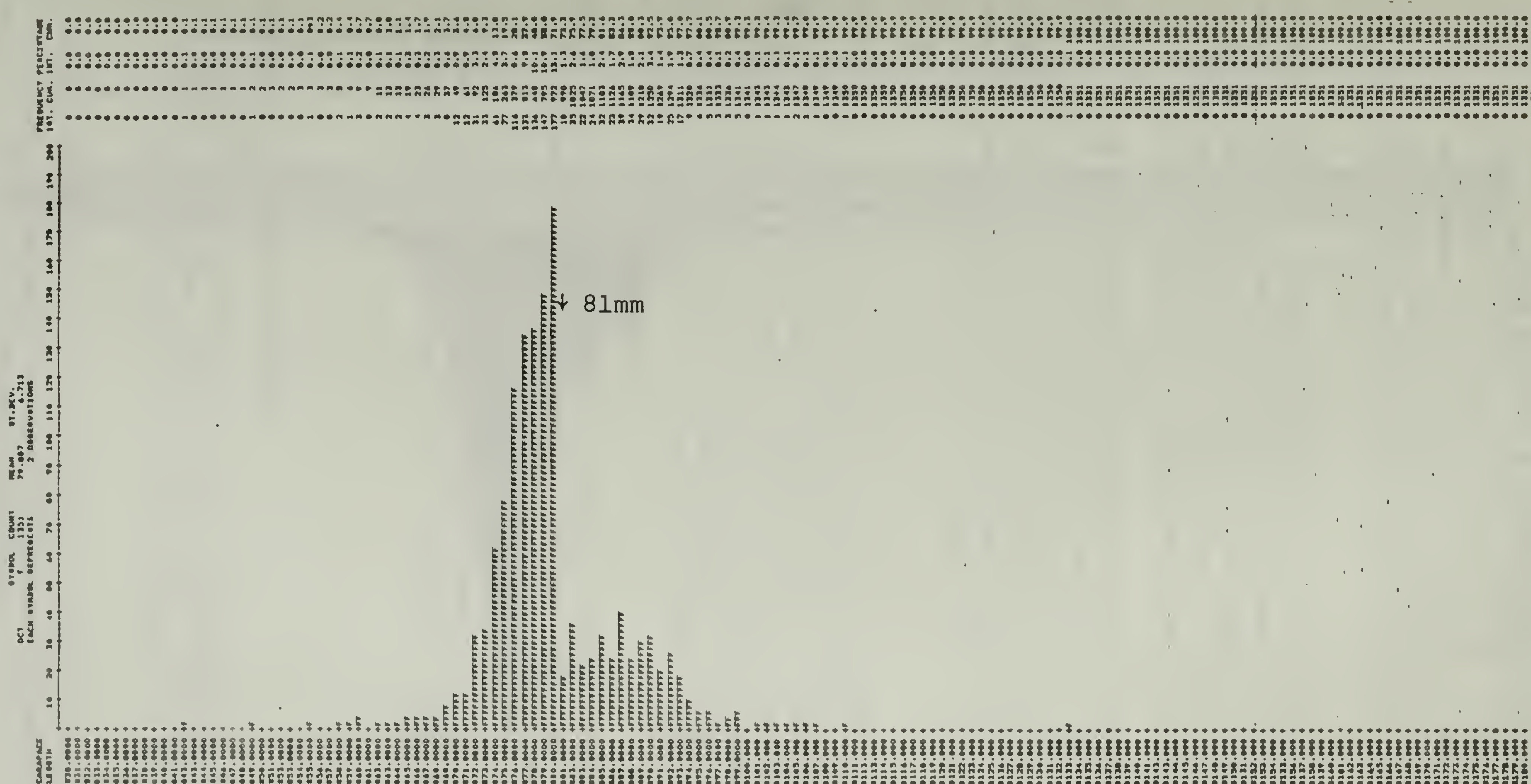


Figure 15. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for all American lobster sampled during October, 1981.

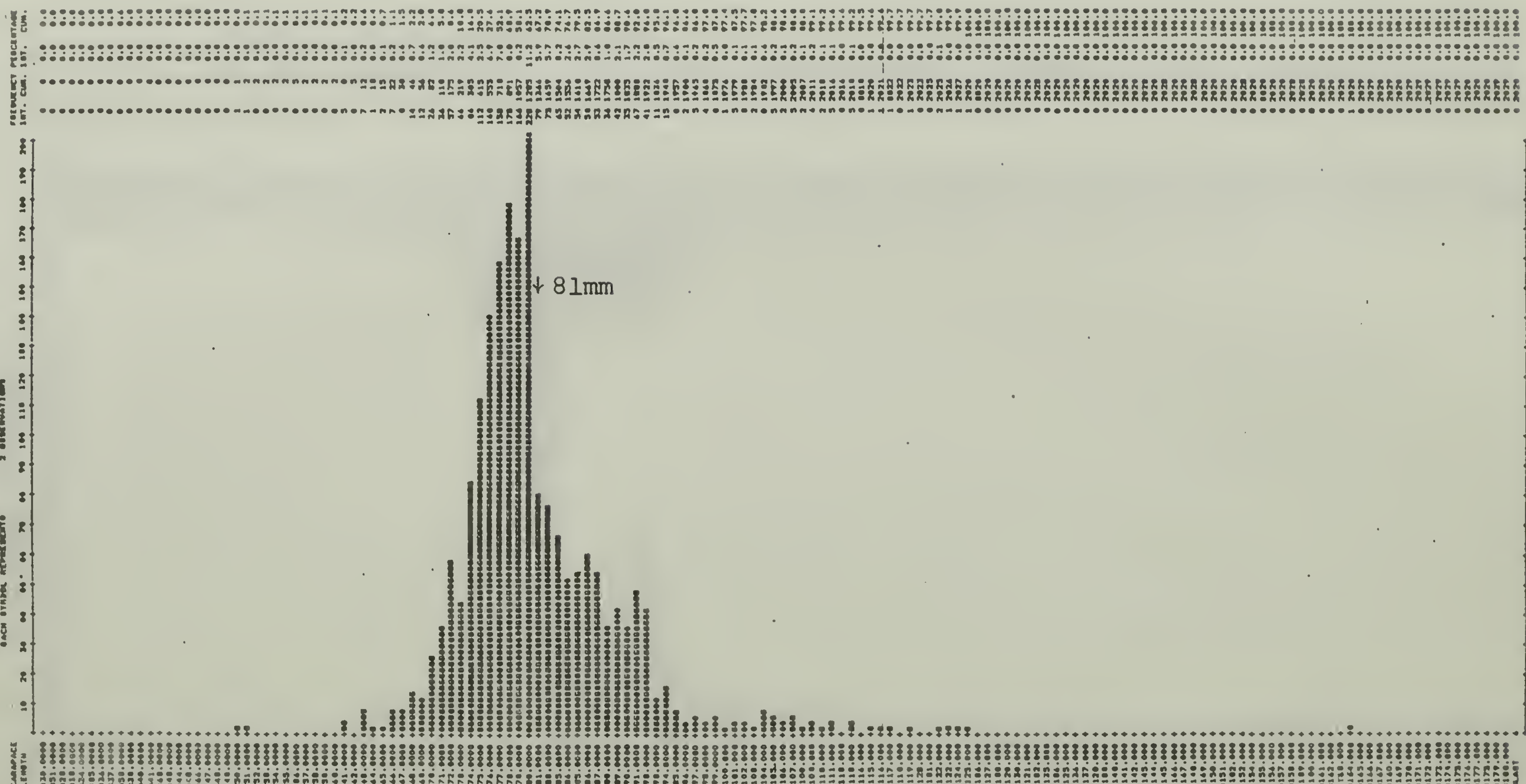


Figure 16. Length frequency histogram with absolute and cumulative (cum.) frequency of observations in 1mm intervals (int.) and their representation in percent for all American lobster sampled during November,1981.

By region, there was an apparent north-south gradient whereby the smallest percentage of berried females, 1.7%, was encountered at the northernmost region off Cape Ann, followed by Beverly-Salem, 1.8%; Cape Cod Bay, 3.8%; outer Cape Cod, 12.4%; and Buzzards Bay, 16.6% ($P < 0.001$). Legal sized berried females followed the same trend. Sublegal berried females were encountered in all regions except Cape Ann and outer Cape Cod but maintained a similar north-south trend (Table 10).

By month, combined length categories, the statewide percentage of berried females peaked in May, declined during summer months, probably as a result of the hatching process, and increased again in November, attributable to newly extruded egg masses ($P < 0.001$, Figure 17, Table 11). Sublegals mirror this trend, but it is only vaguely demonstrated by legals.

Regional indices by month for combined length categories indicate that peaks occur in May and November in Buzzards Bay, and in June and October in Cape Cod Bay, however, the peak in the outer Cape Cod region occurs in August and is probably delayed as a result of the inshore migration of offshore berried females (Briggs and Mushacke 1980, Morrissey 1971). They evidently release their eggs inshore because the November index approximates the May index (Table 12).

Buzzards Bay exhibited a large percentage of sublegal berried females in May, 22.6%, and November, 22.7%, while 46.4% and 41.9% of legal sized females were ovigerous in May and November, respectively. No sublegal ovigerous females were captured in the regions of Cape Ann or outer Cape Cod. The gradual increase in outer Cape Cod legal indices during summer months may have influenced Cape Cod Bay indices, for a concomitant rise occurs in the June legal index in that region (Table 13). However, increased effort and catchability at this time cannot be discounted.

Table 14 indicates that of all ovigerous females captured statewide ($N = 429$), 50.58% were legal sized and 49.42% were sublegal sized.

By region, Buzzards Bay exhibited the greatest percentage of sublegal berried females, 74.29%, followed by Beverly-Salem, 57.14%, and Cape Cod Bay, 38.54%. No sublegal berried females were captured in Cape Ann or outer Cape Cod.

Carapace Length of Ovigerous Females

The statewide average carapace length of egg-bearing females was 85.9 mm and ranged from 69 to 166 mm. Those in the legal size category ($\geq$ 81 mm) averaged 94.5 mm while sublegals ($<$ 81 mm) averaged 77.0 mm (Table 15, Figure 18).

By region, outer Cape Cod exhibited the largest average berried female length of 109.7 mm, followed by Cape Ann, 109.0 mm; Cape Cod Bay, 86.7 mm; Beverly-Salem, 82.3 mm; and Buzzards Bay, 78.7 mm. Sublegal sized berried

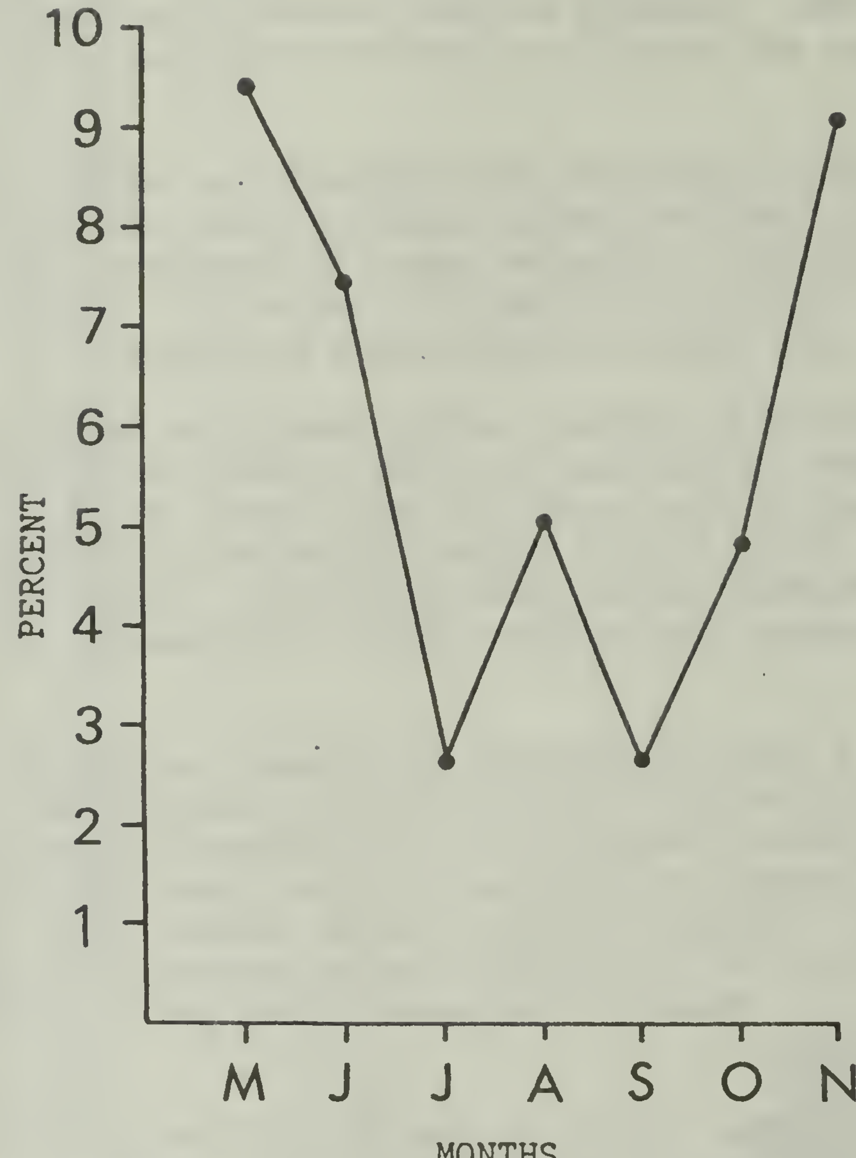


Figure 17. Percent of American lobster females ovigerous by month, regions combined, 1981.

FIGURE 18. LENGTH FREQUENCY HISTOGRAM OF OVIGEROUS FEMALE AMERICAN LOBSTER FROM MASSACHUSETTS ALONG WITH ABSOLUTE AND CUMULATIVE (CUM.) FREQUENCY OF OBSERVATIONS IN 1MM INTERVALS (INT.) AND THEIR REPRESENTATION IN PERCENT, 1981.

	SYMBOL	COUNT	MEAN	ST.DEV.
BERRIED	A	429	85.853	13.285

EACH SYMBOL REPRESENTS 1 OBSERVATIONS

CARAPACE LENGTH	5 10 15 20 25 30 35 40	FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
*69.0000	+A	1	1	0.2	0.2
*70.0000	+AAAA	4	5	0.9	1.2
*71.0000	+A	1	6	0.2	1.4
*72.0000	+AAAAAAA	7	13	1.6	3.0
*73.0000	+AAAAAAAA	8	21	1.9	4.9
*74.0000	+AAAAAAAA	8	29	1.9	6.8
*75.0000	+AAAAAAAAAAAAAA	14	43	3.3	10.0
*76.0000	+AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	36	79	8.4	18.4
*77.0000	+AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	34	113	7.9	26.3
*78.0000	+AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	32	145	7.5	33.8
*79.0000	+AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	35	180	8.2	42.0
*80.0000	+AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	32	212	7.5	49.4
*81.0000	+AAAAAAAAAAAAAAA ← 81mm	15	227	3.5	52.9
*82.0000	+AAAAAAAAAAAA	12	239	2.8	55.7
*83.0000	+AAAAAAAA	8	247	1.9	57.6
*84.0000	+AAAAAAAAAAA	11	258	2.6	60.1
*85.0000	+AAAAAAAAAAAAAA	14	272	3.3	63.4
*86.0000	+AAAAAAAAAAAAAAAA	16	288	3.7	67.1
*87.0000	+AAAAAAAAAAA	11	299	2.6	69.7
*88.0000	+AAAAAAAAAAAAAA	14	313	3.3	73.0
*89.0000	+AAAAAAAA	8	321	1.9	74.8
*90.0000	+AAAAAA	6	327	1.4	76.2
*91.0000	+AAAAAAAAAA	10	337	2.3	78.6
*92.0000	+AAAAAAAAAAA	11	348	2.6	81.1
*93.0000	+AAAAAAAA	8	356	1.9	83.0
*94.0000	+A	1	357	0.2	83.2
*95.0000	+A	1	358	0.2	83.4
*96.0000	+AAAA	4	362	0.9	84.4
*97.0000	+A	1	363	0.2	84.6
*98.0000	+AAA	3	366	0.7	85.3
*99.0000	+AAAA	4	370	0.9	86.2
*100.000	+A	1	371	0.2	86.5
*101.000	+	0	371	0.0	86.5
*102.000	+AA	2	373	0.5	86.9
*103.000	+AAA	3	376	0.7	87.6
*104.000	+AAAAAA	6	382	1.4	89.0
*105.000	+AAA	3	385	0.7	89.7
*106.000	+AAAAAAAAAA	10	395	2.3	92.1
*107.000	+AAA	3	398	0.7	92.8
*108.000	+AA	2	400	0.5	93.2
*109.000	+AA	2	402	0.5	93.7
*110.000	+A	1	403	0.2	93.9
*111.000	+AA	2	405	0.5	94.4
*112.000	+AAA	3	408	0.7	95.1
*113.000	+	0	408	0.0	95.1
*114.000	+A	1	409	0.2	95.3
*115.000	+AA	2	411	0.5	95.8
*116.000	+AAA	3	414	0.7	96.5
*117.000	+A	1	415	0.2	96.7
*118.000	+A	1	416	0.2	97.0
*119.000	+A	1	417	0.2	97.2
*120.000	+	0	417	0.0	97.2
*121.000	+	0	417	0.0	97.2
*122.000	+A	1	418	0.2	97.4
*123.000	+	0	418	0.0	97.4
*124.000	+AA	2	420	0.5	97.9
*125.000	+A	1	421	0.2	98.1
*126.000	+A	1	422	0.2	98.4
*127.000	+	0	422	0.0	98.4
*128.000	+A	1	423	0.2	98.6
*129.000	+	0	423	0.0	98.6
*130.000	+A	1	424	0.2	98.8
*131.000	+	0	424	0.0	98.8
*132.000	+	0	424	0.0	98.8
*133.000	+A	1	425	0.2	99.1
*134.000	+	0	425	0.0	99.1
*135.000	+A	1	426	0.2	99.3
*136.000	+	0	426	0.0	99.3
*137.000	+A	1	427	0.2	99.5
*155.000	+A	1	428	0.2	99.8
*166.000	+A	1	429	0.2	100.0
*LAST	+	0	429	0.0	100.0
	5 10 15 20 25 30 35 40				

females averaged 77.5 mm in Cape Cod Bay, 77.0 mm in Beverly-Salem, and 76.7 mm in Buzzards Bay. None were captured in Cape Ann or outer Cape Cod regions. However, legal sized berried females were captured in all regions. Cape Ann and outer Cape Cod regions exhibited the largest average lengths of 109.0 mm and 109.7 mm, respectively, followed by Cape Cod Bay, 92.4 mm; Beverly-Salem, 89.3 mm; and Buzzards Bay, 84.4 mm (Table 15). Except for Cape Ann, where only two berried females were captured, regional length frequency histograms of berried females are presented in Figures 19-22.

In western Long Island Sound, an area comparable to Buzzards Bay in depth, relatively warmer average water temperature, and restricted access, Briggs and Mushacke (1979) computed a similar average berried female length of 80 mm (range 64-120 mm). While investigating the pot fishery on the south shore of Long Island, Briggs and Mushacke (1980) calculated an average berried female length of 99 mm (range 78-135 mm) and found only nine sublegal eggers. Size distribution in this area was thought to reflect mixing of large offshore migrants. This relatively open area with a greater depth range is comparable to outer Cape Cod and Cape Ann regions which exhibited similar large average egg-bearing female lengths with no ovigerous females < 81 mm. The seasonal influence of an offshore migrant population in the outer Cape Cod region has been documented (Morrissey 1971) and Dow (1974) described the movement of large lobster, tagged off the Maine coast, into Massachusetts waters.

Size at Maturity

Analysis of ovigerous female length frequency has been proven to provide a good relative index of total maturity and size at first maturity (Briggs and Mushacke 1979, Briggs and Mushacke 1980, Marcello et al. 1979, Russell et al. 1978, Thomas 1973, and Skud and Perkins 1969). However, when employing this technique one must distinguish between, for example, size at 50% maturity and size at 50% ovigerous. It is apparent from a study of the literature that not all females are mature after reaching the size at first maturity, nor are all females ovigerous when mature. Depending upon the region, the proportion of females ovigerous may be affected by fishing pressure. Some female lobster may be removed from the population before they have the opportunity to reach maturity or extrude eggs. Also, resorption of lipovittelin occurs commonly with varying intensity and may be related to unfavorable conditions encountered near the expected time of oviposition (Aiken and Waddy 1980). Unlike spent ovaries, however, resorption requires only a one-year recovery period compared to two years before complete ovarian maturation is again possible. A further complication affecting maturity estimates lies in the fact that size classes may contain more than one age class. Consequently, accuracy of maturity estimates may be improved through combining several annual survey data sets.

Nevertheless, it appears that the size at which most females become ovigerous is also an approximate indication of 100% maturity. Skud and Perkins (1969) found that the size at first maturity in lobster sampled from five offshore canyons was 8 cm carapace length. Most were berried from 10 cm and larger, though only 21.9% (16.8 - 67.0%) of all females above 8 cm were ovigerous.

FIGURE 19. LENGTH FREQUENCY HISTOGRAM OF OVIGEROUS FEMALE AMERICAN LOBSTER FROM BEVERLY-SALEM ALONG WITH ABSOLUTE AND CUMULATIVE (CUM.) FREQUENCY OF OBSERVATIONS IN 1MM INTERVALS (INT.) AND THEIR REPRESENTATION IN PERCENT, 1981.

```
                         SYMBOL   COUNT      MEAN      ST.DEV.
               BERRIED     A        14      82.286       8.398
               EACH SYMBOL REPRESENTS          1 OBSERVATIONS
CARAPACE                                 FREQUENCY PERCENTAGE
LENGTH         5    10   15   20   25   INT. CUM.  INT.  CUM.
          +----+----+----+----+----+
*74.0000 +A                               1    1    7.1   7.1
*75.0000 +                                0    1    0.0   7.1
*76.0000 +AA                              2    3   14.3  21.4
*77.0000 +                                0    3    0.0  21.4
*78.0000 +AAAAA                           5    8   35.7  57.1
*79.0000 +                                0    8    0.0  57.1
*80.0000 +                                0    8    0.0  57.1
*81.0000 +                                0    8    0.0  57.1
*82.0000 +A                               1    9    7.1  64.3
*83.0000 +                                0    9    0.0  64.3
*84.0000 +A                               1   10    7.1  71.4
*85.0000 +                                0   10    0.0  71.4
*86.0000 +A                               1   11    7.1  78.6
*87.0000 +A                               1   12    7.1  85.7
*88.0000 +                                0   12    0.0  85.7
*89.0000 +                                0   12    0.0  85.7
*90.0000 +                                0   12    0.0  85.7
*91.0000 +A                               1   13    7.1  92.9
*92.0000 +                                0   13    0.0  92.9
*93.0000 +                                0   13    0.0  92.9
*94.0000 +                                0   13    0.0  92.9
*95.0000 +                                0   13    0.0  92.9
*96.0000 +                                0   13    0.0  92.9
*97.0000 +                                0   13    0.0  92.9
*98.0000 +                                0   13    0.0  92.9
*99.0000 +                                0   13    0.0  92.9
*100.000 +                                0   13    0.0  92.9
*101.000 +                                0   13    0.0  92.9
*102.000 +                                0   13    0.0  92.9
*103.000 +                                0   13    0.0  92.9
*104.000 +                                0   13    0.0  92.9
*105.000 +                                0   13    0.0  92.9
*106.000 +A                               1   14    7.1 100.0
*LAST    +                                0   14    0.0 100.0
          +----+----+----+----+----+
               5    10   15   20   25
```

FIGURE 20. LENGTH FREQUENCY HISTOGRAM OF OVIGEROUS FEMALE AMERICAN LOBSTER FROM CAPE COD BAY ALONG WITH ABSOLUTE AND CUMULATIVE (CUM.) FREQUENCY OF OBSERVATIONS IN 1MM INTERVALS (INT. AND THEIR REPRESENTATION IN PERCENT, 1981

	SYMBOL	COUNT	MEAN	ST.DEV.
BERRIED	A	192	86.677	10.937

EACH SYMBOL REPRESENTS 1 OBSERVATIONS

CARAPACE LENGTH	5 10 15 20 25	FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
	+----+----+----+----+----+				
*70.0000	+A	1	1	0.5	0.5
*71.0000	+	0	1	0.0	0.5
*72.0000	+	0	1	0.0	0.5
*73.0000	+AAA	3	4	1.6	2.1
*74.0000	+AA	2	6	1.0	3.1
*75.0000	+AAA	3	9	1.6	4.7
*76.0000	+AAAAAAAAAAAA	12	21	6.3	10.9
*77.0000	+AAAAAAAAAAAAA	13	34	6.8	17.7
*78.0000	+AAAAAAAAAAAA	12	46	6.3	24.0
*79.0000	+AAAAAAAAAAAAAA	14	60	7.3	31.3
*80.0000	+AAAAAAAAAAAAAA	14	74	7.3	38.5
*81.0000	+AAAAAA ← 81mm	6	80	3.1	41.7
*82.0000	+AAAAAAAA	8	88	4.2	45.8
*83.0000	+AAA	3	91	1.6	47.4
*84.0000	+A	1	92	0.5	47.9
*85.0000	+AAAAAAAAA	9	101	4.7	52.6
*86.0000	+AAAAAAAAAAA	11	112	5.7	58.3
*87.0000	+AAAAA	5	117	2.6	60.9
*88.0000	+AAAAAAAAAA	10	127	5.2	66.1
*89.0000	+AAAAAAA	7	134	3.6	69.8
*90.0000	+AAAAA	5	139	2.6	72.4
*91.0000	+AAAAAAAA	8	147	4.2	76.6
*92.0000	+AAAAA	5	152	2.6	79.2
*93.0000	+AAAAAA	6	158	3.1	82.3
*94.0000	+A	1	159	0.5	82.8
*95.0000	+A	1	160	0.5	83.3
*96.0000	+AAAA	4	164	2.1	85.4
*97.0000	+A	1	165	0.5	85.9
*98.0000	+AAA	3	168	1.6	87.5
*99.0000	+AAA	3	171	1.6	89.1
*100.000	+	0	171	0.0	89.1
*101.000	+	0	171	0.0	89.1
*102.000	+A	1	172	0.5	89.6
*103.000	+AA	2	174	1.0	90.6
*104.000	+AA	2	176	1.0	91.7
*105.000	+A	1	177	0.5	92.2
*106.000	+AAAA	4	181	2.1	94.3
*107.000	+AA	2	183	1.0	95.3
*108.000	+A	1	184	0.5	95.8
*109.000	+A	1	185	0.5	96.4
*110.000	+	0	185	0.0	96.4
*111.000	+	0	185	0.0	96.4
*112.000	+AA	2	187	1.0	97.4
*113.000	+	0	187	0.0	97.4
*114.000	+	0	187	0.0	97.4
*115.000	+A	1	188	[illegible]	97.9
*116.000	+	0	188	0.0	97.9
*117.000	+	0	188	0.0	97.9
*118.000	+	0	188	0.0	97.9
*119.000	+A	1	189	0.5	98.4
*120.000	+	0	189	0.0	98.4
*121.000	+	0	189	0.0	98.4
*122.000	+A	1	190	0.5	99.0
*133.000	+A	1	[illegible]	[illegible]	99.5
*135.000	+A	1	[illegible]	0.5	100.0
*LAST	+	0	[illegible]	[illegible]	100.0
	+----+----+----+----+----+				
	5 10 15 20 25				

FIGURE 21. LENGTH FREQUENCY HISTOGRAM OF OVIGEROUS FEMALE AMERICAN LOBSTER FROM OUTER CAPE COD ALONG WITH ABSOLUTE AND CUMULATIVE (CUM.) FREQUENCY OF OBSERVATIONS IN 1MM INTERVALS (INT.) AND THEIR REPRESENTATION IN PERCENT, 1981.

	SYMBOL	COUNT	MEAN	ST.DEV.
BERRIED	A	46	109.739	16.318

EACH SYMBOL REPRESENTS 1 OBSERVATION

CARAPACE LENGTH	5 10 15	FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.
	+----+----+----+				
*86.0000	+A	1	1	2.2	2.2
*87.0000	+	0	1	0.0	2.2
*88.0000	+A	1	2	2.2	4.3
*89.0000	+	0	2	0.0	4.3
*90.0000	+	0	2	0.0	4.3
*91.0000	+A	1	3	2.2	6.5
*92.0000	+AAAAA	5	8	10.9	17.4
*93.0000	+AA	2	10	4.3	21.7
*94.0000	+	0	10	0.0	21.7
*95.0000	+	0	10	0.0	21.7
*96.0000	+	0	10	0.0	21.7
*97.0000	+	0	10	0.0	21.7
*98.0000	+	0	10	0.0	21.7
*99.0000	+A	1	11	2.2	23.9
*100.000	+A	1	12	2.2	26.1
*101.000	+	0	12	0.0	26.1
*102.000	+A	1	13	2.2	28.3
*103.000	+A	1	14	2.2	30.4
*104.000	+AAAA	4	18	8.7	39.1
*105.000	+AA	2	20	4.3	43.5
*106.000	+AAAAA	5	25	10.9	54.3
*107.000	+	0	25	0.0	54.3
*108.000	+A	1	26	2.2	56.5
*109.000	+A	1	27	2.2	58.7
*110.000	+A	1	28	2.2	60.9
*111.000	+A	1	29	2.2	63.0
*112.000	+A	1	30	2.2	65.2
*113.000	+	0	30	0.0	65.2
*114.000	+A	1	31	2.2	67.4
*115.000	+A	1	32	2.2	69.6
*116.000	+AAA	3	35	6.5	76.1
*117.000	+A	1	36	2.2	78.3
*118.000	+A	1	37	2.2	80.4
*119.000	+	0	37	0.0	80.4
*120.000	+	0	37	0.0	80.4
*121.000	+	0	37	0.0	80.4
*122.000	+	0	37	0.0	80.4
*123.000	+	0	37	0.0	80.4
*124.000	+AA	2	39	4.3	84.8
*125.000	+A	1	40	2.2	87.0
*126.000	+A	1	41	2.2	89.1
*127.000	+	0	41	0.0	89.1
*128.000	+A	1	42	2.2	91.3
*129.000	+	0	42	0.0	91.3
*130.000	+A	1	43	2.2	93.5
*137.000	+A	1	44	2.2	95.7
*155.000	+A	1	45	2.2	97.8
*166.000	+A	1	46	2.2	100.0
*LAST	+	0	46	0.0	100.0
	+----+----+----+				
	5 10 15				

FIGURE 22. LENGTH FREQUENCY HISTOGRAM OF OVIGEROUS FEMALE AMERICAN LOBSTER FROM BUZZARDS BAY ALONG WITH ABSOLUTE AND CUMULATIVE (CUM.) FREQUENCY OF OBSERVATIONS IN 1MM INTERVALS (INT.) AND THEIR REPRESENTATION IN PERCENT, 1981.

```
                 SYMBOL   COUNT      MEAN      ST.DEV.
    BERRIED        A       175      78.691       4.273
    EACH SYMBOL REPRESENTS            1 OBSERVATION

CARAPACE                                              FREQUENCY PERCENTAGE
LENGTH            5    10   15   20   25   30     INT. CUM. INT.  CUM.
         +----+----+----+----+----+----+
*65.0000 +                                           0    0   0.0    0.0
*66.0000 +                                           0    0   0.0    0.0
*67.0000 +                                           0    0   0.0    0.0
*68.0000 +                                           0    0   0.0    0.0
*69.0000 +A                                          1    1   0.6    0.6
*70.0000 +AAA                                        3    4   1.7    2.3
*71.0000 +A                                          1    5   0.6    2.9
*72.0000 +AAAAAAA                                    7   12   4.0    6.9
*73.0000 +AAAAA                                      5   17   2.9    9.7
*74.0000 +AAAAA                                      5   22   2.9   12.6
*75.0000 +AAAAAAAAAAA                               11   33   6.3   18.9
*76.0000 +AAAAAAAAAAAAAAAAAAAAAA                    22   55  12.6   31.4
*77.0000 +AAAAAAAAAAAAAAAAAAAAA                     21   76  12.0   43.4
*78.0000 +AAAAAAAAAAAAAAA                           15   91   8.6   52.0
*79.0000 +AAAAAAAAAAAAAAAAAAAAA                     21  112  12.0   64.0
*80.0000 +AAAAAAAAAAAAAAAAAA                        18  130  10.3   74.3
*81.0000 +AAAAAAAAA                                  9  139   5.1   79.4
*82.0000 +AAA                                        3  142   1.7   81.1
*83.0000 +AAAAA                                      5  147   2.9   84.0
*84.0000 +AAAAAAAAA                                  9  156   5.1   89.1
*85.0000 +AAAAA                                      5  161   2.9   92.0
*86.0000 +AAA                                        3  164   1.7   93.7
*87.0000 +AAAAA                                      5  169   2.9   96.6
*88.0000 +AAA                                        3  172   1.7   98.3
*89.0000 +A                                          1  173   0.6   98.9
*90.0000 +A                                          1  174   0.6   99.4
*91.0000 +                                           0  174   0.0   99.4
*92.0000 +A                                          1  175   0.6  100.0
*93.0000 +                                           0  175   0.0  100.0
*94.0000 +                                           0  175   0.0  100.0
*95.0000 +                                           0  175   0.0  100.0
*LAST    +                                           0  175   0.0  100.0
         +----+----+----+----+----+----+
                  5    10   15   20   25   30
```

An analysis of ovarian development and second segment width indicated that all females $\geq$ 10 cm were actually mature.

These data are most comparable with data from the outer Cape Cod region. The percentage of females ovigerous was grouped by 5 mm intervals to reduce variability and plotted. Tentatively, size at first maturity was found to be 85-89 mm with the majority berried after 100 mm (Figure 23).

In Cape Cod Bay, size at first maturity was found to be 70-74 mm with most females becoming mature by 90-94 mm (Figure 24).

The size at first maturity in Buzzards Bay was 65-69 mm. Most were ovigerous and with good probability mature by the time they reached 80-85 mm (Figure 25). In the neighboring inshore area of R. I. Sound, Russel et al. (1978) found the onset of maturity to be 70-73 mm with 50% maturity (ovigerous) at 92-93 mm. In western Long Island Sound, Briggs and Mushacke (1979) found females to reach first maturity at 60-64 mm with most mature by 80 mm.

Morrissey [ed.] (1975) noted a relationship between environment and size at maturity. Areas where maturity is reached at less than 70 mm are characterized by higher summer temperatures (about 20°C), confined water circulation and exchange, and high population density. However, areas where maturity was not reached until after 85 mm were generally in or adjacent to oceanic waters with relatively low summer temperatures (10°C).

Since a total of only 16 berried females were captured in the regions of Beverly-Salem and Cape Ann, maturity estimates for these regions were deemed impractical.

When all data are pooled to yield a statewide average maturity index, it is suggested from Figure 26 that most lobster are mature by 95-99 mm carapace length.

A preliminary graphical analysis of second segment width-carapace length ratios taken during experimental lobster pound sampling and commercial lobster pot sampling during 1980 support Buzzards Bay and Cape Cod Bay maturity estimates. A complete treatment will be presented in the 1982 annual report. Insufficient data precluded a similar analysis for the outer Cape Cod region.

Sex Ratio

The statewide male to female ratio, expressed in percent, was 41/59. The ratio for legal-sized lobster was 44/56 and for sublegals, 39/61 ($P < 0.001$, Table 16).

Regional ratios did not vary much from the statewide proportion ranging from 39/61 to 44/56 yet differences were statistically significant ($P < 0.001$). By length category, legal ratios approached 50/50, while a predominance of sublegal females occurred in Cape Ann and Cape Cod Bay (Table 16).

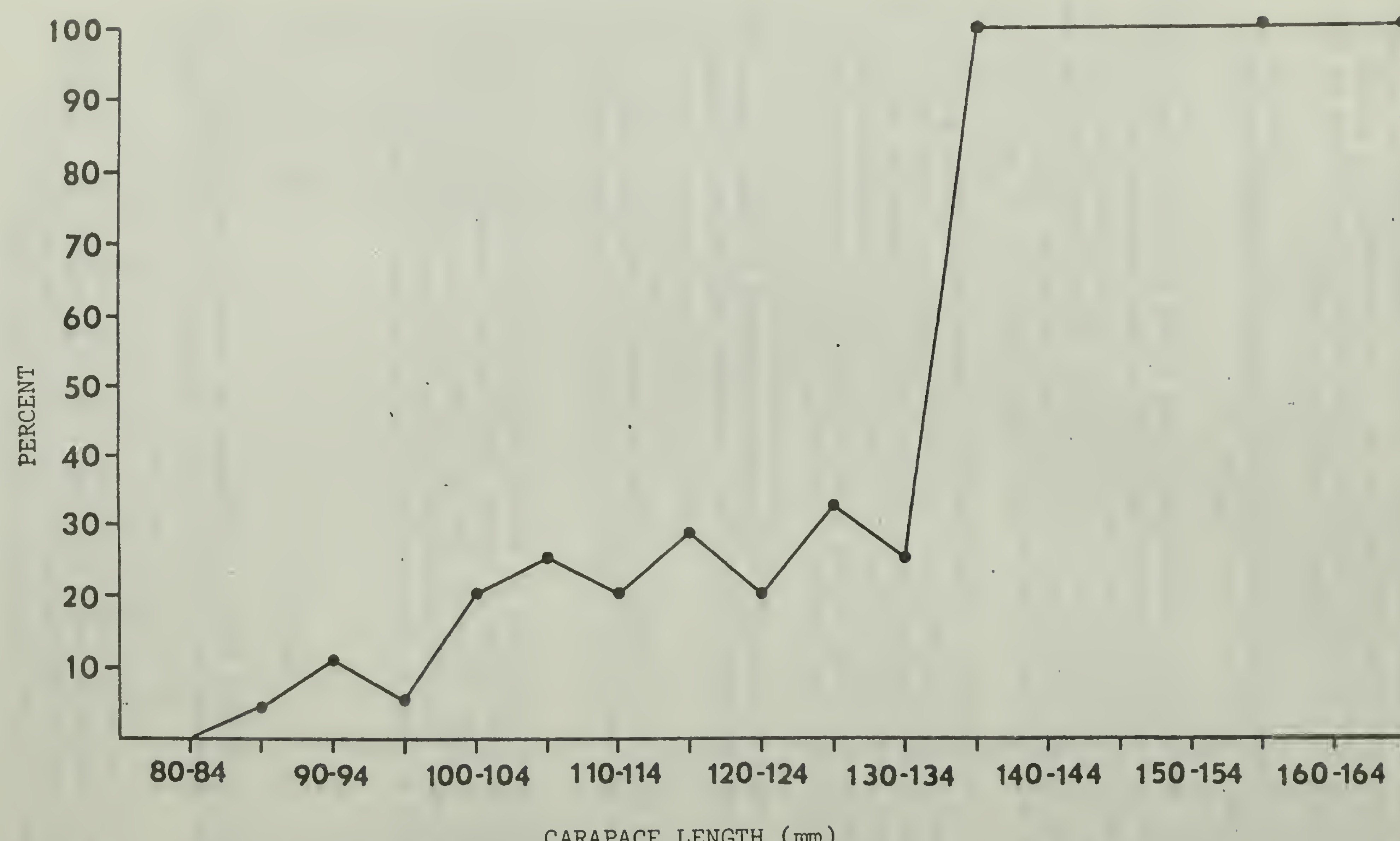


Figure 23. Percent of American lobster females ovigerous in 5mm size groups, outer Cape Cod region, 1981.

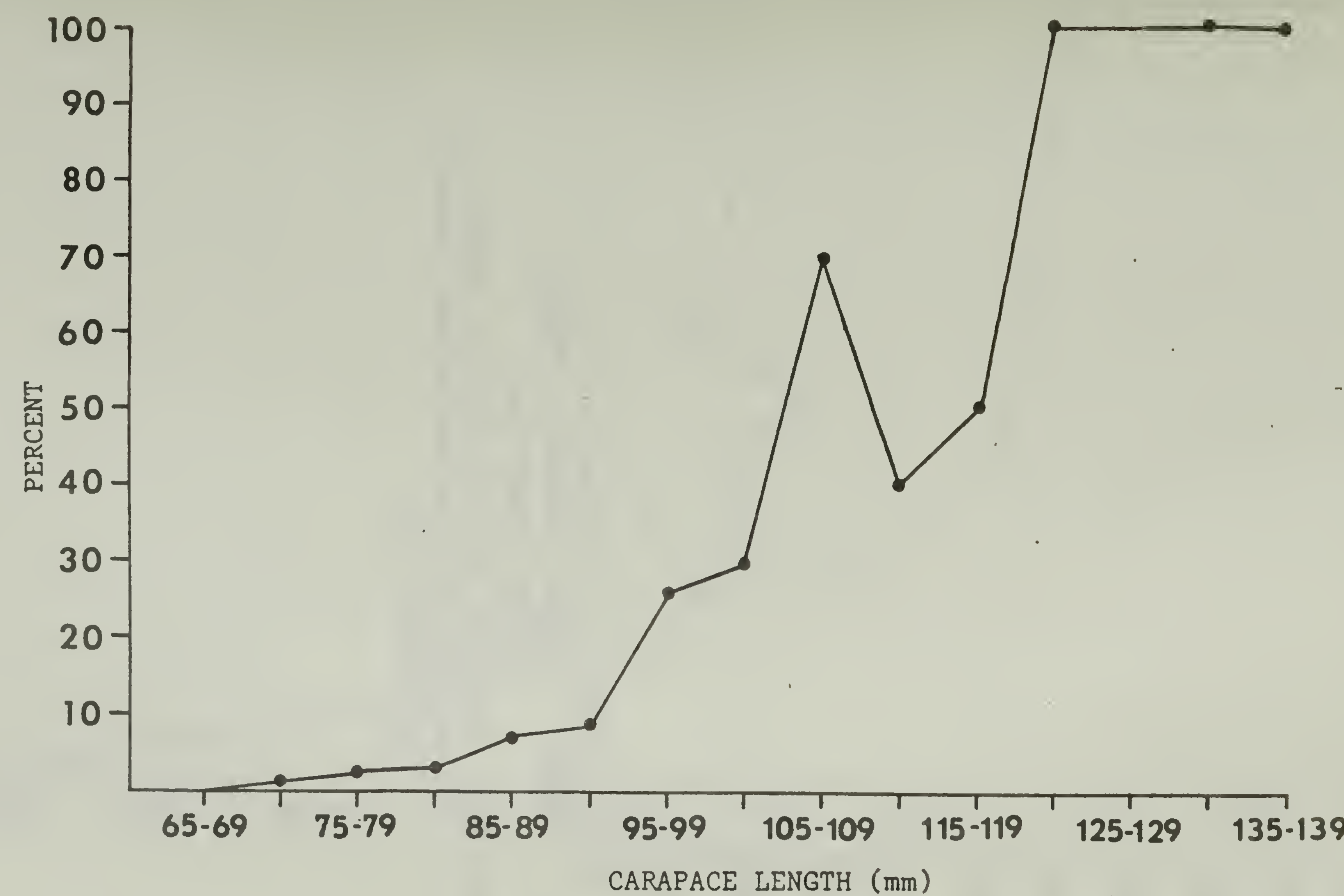


Figure 24. Percent of American lobster females ovigerous in 5 mm size groups, Cape Cod Bay region, 1981.

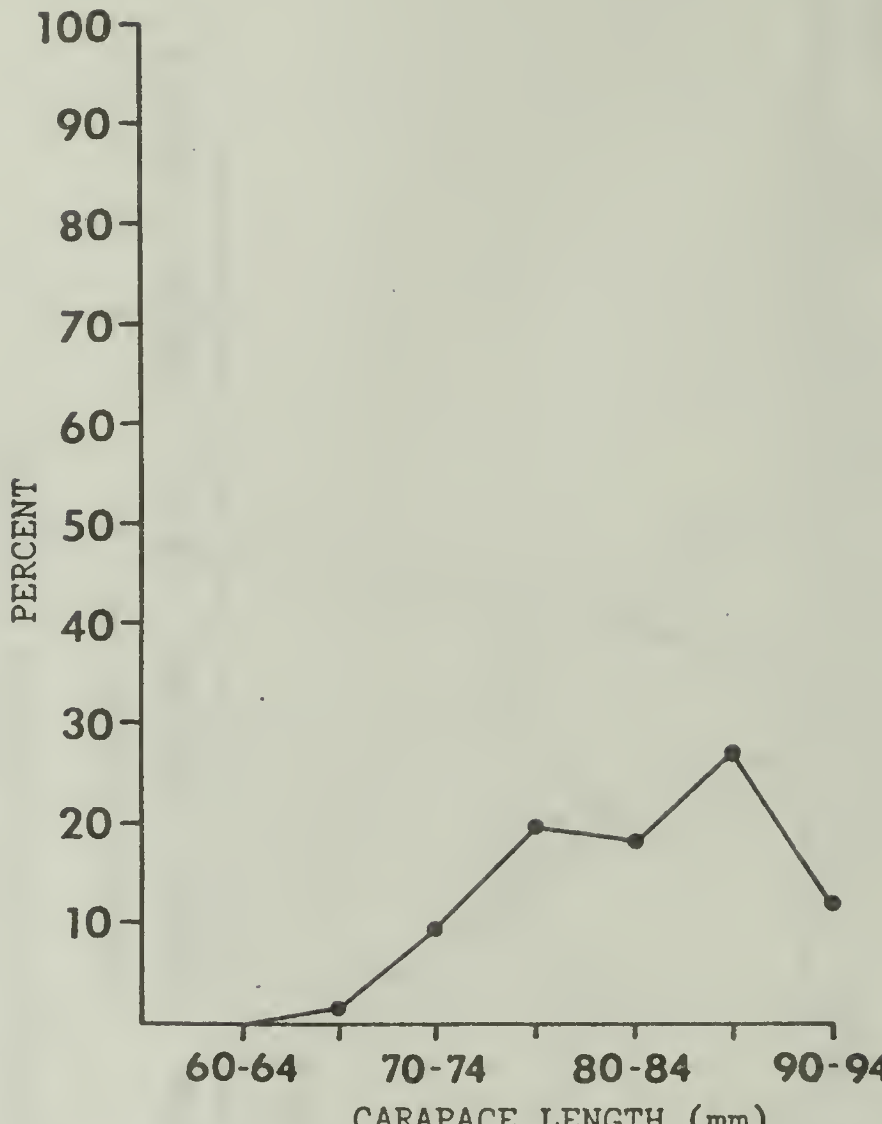


Figure 25. Percent of American lobster females ovigerous in 5 mm size groups, Buzzards Bay region, 1981.

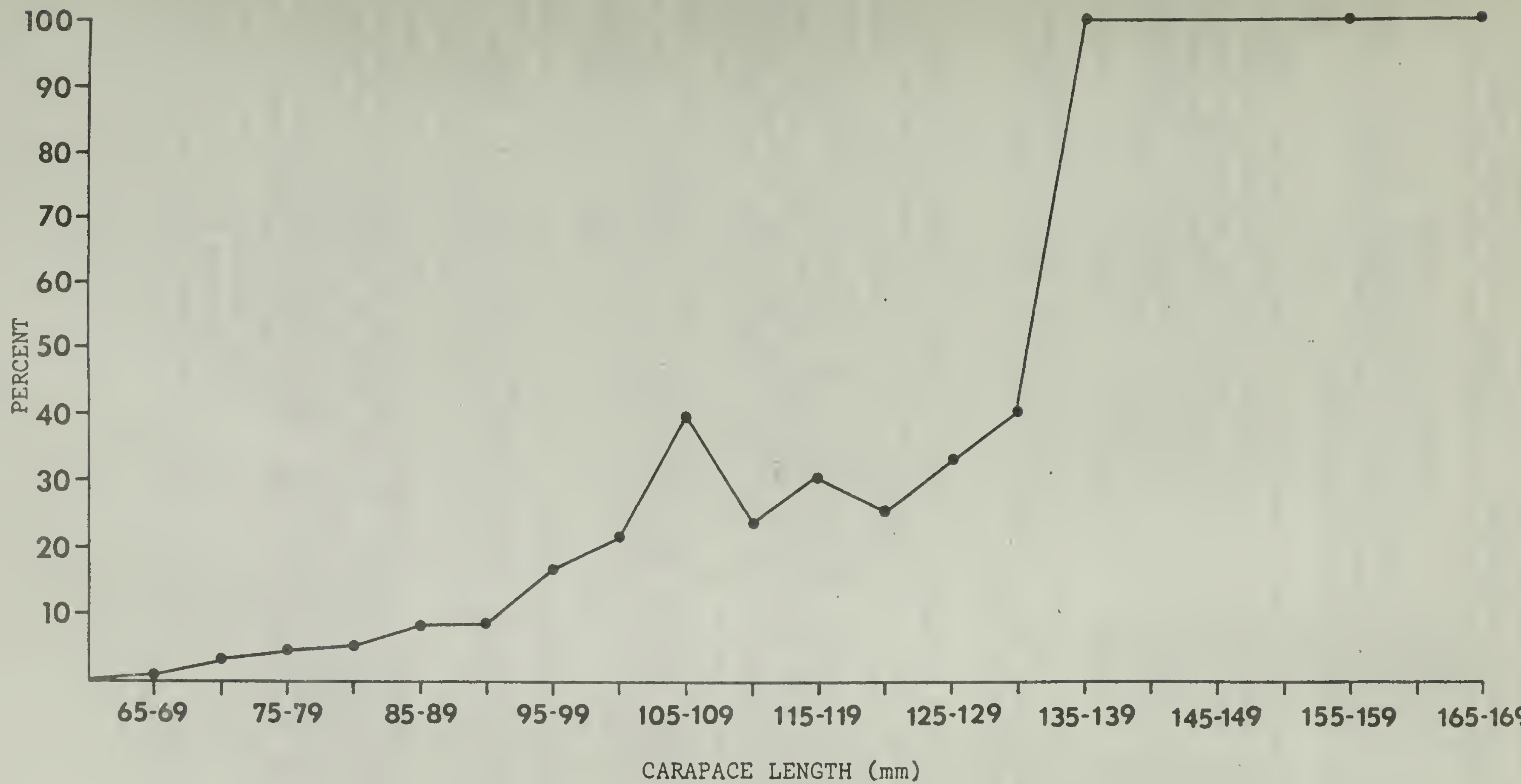


Figure 26. Percent of American lobster females ovigerous in 5 mm size groups, regions combined, 1981.

By month, the statewide average sex ratio ranged from 39/61 to 43/57. Differences were statistically significant (P=.013). Legal ratios ranged from 40/60 to 51/49 while sublegal ratios exhibited fewer males and ranged from 37/63 to 40/60 (Table 17).

Regional ratios by month for combined length categories (Table 18) and legals and sublegals (Table 19) demonstrate no clear trend other than a predominance of females in nearly all crosstabulations.

In Narragansett Bay and Rhode Island Sound, Fogarty and Borden (1980) found differential escapement by males and females biased the ratio toward females. A subsequent investigation revealed a relatively broader carapace width for females. However, no significant difference was found in the carapace width-length relationship in Maine (Krouse and Thomas 1975). Unlike the Massachusetts sublegal sex ratio (39/61), sublegal lobster near Boothbay Harbor, Maine approximated a 1:1 sex ratio (Krouse 1973).

Indications are that sex ratio may also vary with depth, with females preferring deeper water than males (Briggs and Mushacke 1979, Briggs and Zawacki 1974, Skud and Perkins 1969).

Molting

The molt cycle of a lobster population can be defined by temporally noting the percentage of lobster with incompletely hardened shells. The hardening process may vary with diet, water temperature, and age (Cobb 1976) but is estimated to take an average of 10 days. All lobster sampled were subjectively assessed as to their degree of shell hardness, categorizing them as "soft" (when carapace does not spring back after extering lateral pressure with fingertips), "papershell" (when carapace does spring back), or "hardshell" (no resilience). Lobster with other than hard shells were considered to have recently molted. It should be noted that this index is designed to determine the molt period and is only a relative index of the total number of lobster which actually do molt at a given time.

The statewide percentage of recently molted lobster was 2.5%. Among legal sized lobster, 3.4% had recently molted while only 2.0% of sublegals had soft or papershells ($P < 0.001$, Table 20). Indices were 3.6% for males and 1.7% for females ($P < 0.001$). This disparity is probably influenced by the egg-bearing females in the catch which do not molt until the hatching process is completed (two-year cycle). As was noted by Briggs and Mushacke (1979), there is some evidence that females peak later than males. Pooled data below indicate male indices are higher than female indices in June with the reversal occurring, at least for legal sized lobster, in July and August:

	Males		Females	
	Legal	Sublegal	Legal	Sublegal
May	0.00	0.25	0.34	0.16
June	9.13	5.41	3.53	1.67
July	1.95	0.92	2.03	0.37
August	1.21	1.41	3.57	0.73
September	0.65	0.15	0.00	0.38
October	0.66	0.26	0.00	0.34
November	14.50	10.39	5.81	5.68

By region, for combined length categories, Buzzards Bay ranked highest in recently molted lobster with 13.1% and was statistically different from all other regions. Cape Ann ranked second with 2.5%, followed by Beverly-Salem, 1.5%; outer Cape Cod, 0.8%, and Cape Cod Bay, 0.4%. The percentage of recently molted legal sized lobster was 24.9% in Buzzards Bay, 3.3% off Cape Ann, 2.8% off Beverly-Salem, 0.7% off outer Cape Cod, and 0.5% in Cape Cod Bay. Except for Cape Ann, where no sublegal molt incidence was encountered, the sublegal trend was similar to that of legals (Table 20).

Newly molted lobster were encountered in all months sampled, however, statewide peaks occurred in June, 3.9%, and November, 8.3%, and were significantly different from all other months. Both legals and sublegals exhibited similar trends (Table 21).

Regional indices by month (combined length categories) indicate that Cape Cod Bay and outer Cape Cod regions peaked in July (Table 22). In Cape Cod Bay, sublegals peaked in June and November while legals peaked in July and tapered off to zero in November (Table 23).

Buzzards Bay exhibited very high frequencies of "shedders" for all lobster and legal and sublegal length categories (Tables 19, 21, and 22). The higher average water temperature in this region probably enhances molt frequency and under unusually high temperatures may overcome the normal fall-winter molt refractory period (Aiken and Waddy 1976). Such an event was documented in Buzzards Bay during winter 1980-81 where high incidences of soft-shelled lobster were encountered by local lobstermen (Estrella 1981). Briggs and Mushacke (1979) found soft-shelled lobster in January, 1976 in western Long Island Sound and speculated whether this was due to a winter molt or delayed shell hardening from the fall molt as a result of low water temperature.

Culls

Of all lobster sampled, 11.3% had one or both major claws (chelae) missing or regenerating. For males, this cull rate was 10.9% and for females, 11.6%, but the difference was not significant. Legal sized lobster had a cull rate of 9.3%, significantly different from the 12.3% cull rate of sublegal sized lobster ($P < 0.001$, Table 24). No significant difference was found by trap type (wood vs. wire).

Be region, Buzzards Bay ranked significantly higher than all other regions with a 14.6% cull rate, followed by Cape Cod Bay, 11.6%; Cape Ann, 10.0%; Beverly-Salem, 7.8%; outer Cape Cod, 5.6% ($P < 0.001$, Table 24). A relationship between cull rate and fishing pressure is suggested by the fact that the regions with the highest and lowest cull rates, i.e. Buzzards Bay and outer Cape Cod, respectively, also exhibit the highest and lowest exploitation rates.

By month, the general statewide trend for all lobster was lowest in May and November and high through the summer months with a peak in June ($P < 0.001$). Seasonal trends by length category were similar (Table 25). The June peak may be due in part to the combined effects of escalated effort during fair weather and susceptibility to damage as a result of the molt. Indices were generally higher for sublegals than for legals, a bias which is assumed related to the fact that, following handling, sublegals are returned to the sea with the high probability of future entrapments. Similar seasonal and sublegal trends have been reported by Briggs and Mushacke (1979) and Briggs and Mushacke (1980), respectively.

Regional indices by month for all lobster and length categories (Tables 26 and 27), substantiate the statewide seasonal trend exhibited by Table 25 with few exceptions. The most noteable is the comparatively higher cull rate exhibited by Buzzards Bay legal sized lobster in May (21.4%). This rate is unusual for spring catches and may be correlated with the previous anomalous molt period and subsequent high incidence of soft-shelled lobster reported throughout the winter months in Buzzards Bay (Estrella 1981).

The cull rates for legal lobster by state and region (excluding berried females), are listed in Table 24, but vary little from previously described patterns.

The incidence of lobster body damage or damage to appendages other than major chelae was comparatively low at 0.15% reported statewide for all lobster sampled.

Pathology

Lobster susceptibility to disease may be directly influenced by environmental stress which generally surfaces in visual pathological symptoms. Consequently, regular monitoring of these symptoms was incorporated into the

study. However, because of the nature of the survey and the limitations experienced in sea sampling on a commercial lobster vessel, it was deemed impractical to search for anything but gross visual symptoms of shell disease. The most important are shell discoloration, erosion and ulceration.

In addition, a search for nemertean parasites on lobster egg masses was undertaken.

Shell Disease

The etiology of shell disease has been described in detail (Sinderman 1970, Rosen 1970, Stewart 1980). The shell is enveloped by a thin outer layer of proteolipid material, the epicuticle, which is inert to biochemical attack but, subject to mechanical abrasion. Beneath this layer are three chitinous layers: an exocuticle (calcified pigmented layer), a calcified endocuticle, and a non-calcified endocuticle. Shell disease generally results from an initial external injury, followed by an invasion of chitin consuming (chitinoclastic) microorganisms which expose the calcium carbonate. Subsequent gradual erosion through tunneling and pitting uncovers the epithelium and creates a necrotic lesion (Dow et al. 1975, Stewart 1980).

It is not certain whether the causative agent is fungal or bacterial in nature, however, chitinoclastic bacteria have been isolated from lesions and subsequent laboratory inducement of the disease accomplished.

Fisher et al. (1976) showed diet was more important than mechanical damage in establishing this syndrome in juvenile American lobster, indicating deficiencies in epicuticular repair following ecdysis. More cases were found in postmolt lobster than in those approaching ecdysis due to nutritional deficiencies affecting new shell formation (Malloy 1978).

Nevertheless, extremely high incidences of shell disease have been reported in the wild from areas of environmental degradation. Lobster and crabs collected near dumping grounds receiving large quantities of sewage sludge and dredge spoils were found to commonly exhibit appendage and gill erosion (Young and Pearce 1975). Gapolin and Young (1975) discovered a high prevalence of 15% shell disease in Crangon septemspinosa samples from New York Bight while it was only rarely observed at control sights of Beaufort, NC and Woods Hole, MA.

In the present study, the reported incidence of shell disease was the percentage of lobster exhibiting evidence of shell discoloration, erosion, or ulceration. The statewide incidence of shell disease was 0.15%. Males averaged 0.18% and females 0.14%. The legal size group displayed 0.17% incidence while 0.14% of sublegal sized lobster exhibited symptoms. Differences between sex and length category were not statistically significant (Table 28).

Though shell disease was found to occur in all regions, indices were statistically homogenous (Table 28). By month, tests revealed no statistically significant trends (Tables 29-31).

Shell disease incidence was very low, in most cases less than 1.0% indicating concentrations of pollution-associated microorganisms are well within normal limits in our coastal waters. This conclusion is corroborated by a rock crab analysis conducted by the National Marine Fisheries Service Pathobiology Division. As a result of a cooperative effort with the Massachusetts Division of Marine Fisheries, 107 rock crabs were collected from Cape Cod Bay on 12 May, 1980. Specimens yielded a low incidence of gill discoloration (fouling and necrosis associated with ocean disposal) and supported earlier observations that rock crabs with completely blackened gills are rarely, if ever, found in areas which are not in proximity to ocean disposal sites.[1]

Parasites

A recently discovered nemertean species, tentatively assigned to the genus *Carcinonemertes* by Fleming (1979), has initiated concern due to its habit of actively ingesting lobster eggs (Aiken et al. 1980). Its known distribution extends from the Bay of Fundy and outer Nova Scotia south to Boothbay Harbor, Maine. Whether low water temperature is a factor governing its range is not known, however, no nemertean parasites were reported from lobster sampled in Massachusetts coastal waters.

Trap Mortality

Only 0.09% of all lobster sampled were found dead in traps. Incidence was 0.12% for males and 0.07% for females. Legal and sublegal size groups exhibited 0.07% and 0.10% mortality, respectively. Differences between sex and length category were not significant. Dead lobster were reported only from outer Cape Cod and Buzzards Bay (Table 32). No clear seasonal trends were discernible (Tables 33-35).

Lobster mortality in the wild may be attributed to a number of causes (Sinderman 1979). Gaffkemia, a naturally occurring disease of the blood, has received the greatest notoriety as a potential lobster killer. It has claimed many crustaceans in lobster impoundments in Maine, however, no one has been able to assess its contribution to natural mortality. Young (1973) related documented lobster mortality off the New Jersey coast to a possible synergistic effect of low dissolved oxygen, high temperatures and gill fouling due to copious suspended flocculated material. McLeese and Wilder (1964) found death ensued when the chitinous covering of the gills is attacked by shell disease, subsequently interfering with respiration.

Temperature, salinity, pollution, predation and aggression, may be particularly detrimental during stressful periods such as ecdysis. It is at this time that lobster are most vulnerable, particularly to predation.

[1]NEFC (Northeast Fisheries Center) News, May 1980.

The crowded conditions that potentially can occur in a lobster trap enhance agressive behavior which is less frequently displayed in the wild. (Atema and Cobb 1980). Such behavior may be particularly lethal to relatively defenseless, recently molted lobster.

SUMMARY

The value of this long-term American lobster monitoring program, and the baseline data reported here, lies in the capability it provides to delineate trends in population parameters, forecast conditions in the fishery and make sound management decisions. Findings support previous studies which contend that Gulf of Maine (Cape Cod Bay, Beverly-Salem and Cape Ann) outer Cape Cod and Buzzards Bay lobster groups differ in length-frequency, growth rate, size at maturity, and migratory habits.

The underlying factors maintaining the integrity of these groups are the unique shape of the Massachusetts coastline and its role as an effective temperature barrier. The relatively warmer summer water temperatures experienced by Buzzards Bay lobster produce an accelerated growth rate evidenced by the highest frequency of new-shelled lobster (13.1%) and the smallest size at 100% maturity (80-85 mm) in the state. This environment is also responsible for producing the largest percentage of ovigerous females (and sublegal sized ovigerous females) contributing to historically high record larval densities in that embayment (Lux et al. 1980) and the highest sublegal to legal ratio in the state. Buzzards Bay exhibits the smallest average size for all lobster (and legal length category) which may be correlated with fishing pressure; its exploitation rate is highest in the state.

The outer Cape Cod segment of the Massachusetts population is seasonally augmented by shoalward migration of offshore stocks. Large egg-bearing females comprise a significant percentage of this group. The relatively small percentage of ovigerous females in the Gulf of Maine emphasizes the importance of both Buzzards Bay and outer Cape Cod lobster groups to sustenance of the inshore fishery. Outer Cape Cod exhibits the largest average size which is a function of low exploitation rate and migratory behavior of most of these lobster.

Gulf of Maine lobster are intermediate in average size, exploitation rate, size at 100% maturity, sublegal to legal ratio and percent sublegal ovigerous females. This group exhibited the lowest overall percent of ovigerous females and percent new-shelled lobster.

Females outnumbered males in most crosstabulations. There is some evidence that the female molt peak may lag one month behind that of males.

The statewide cull rate was 11.3% ranging from 5.6% in outer Cape Cod to 14.6% in Buzzards Bay. Evidence suggests it may be correlated with fishing pressure.

Statewide shell disease incidence was less than 1% indicating concentrations of pollution associated organisms are well within normal limits in our coastal waters. Trap mortality incidence was less than 1% and no nemertean parasites were reported from lobster egg masses.

Wire traps were found to outfish wooden traps for any given bait type, region or month. Among baits used, flounder ranked first and herring second in total lobster caught.

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Table 1. Catch per trap-haul per set-over-day by state and region for all American lobster, and legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

		$\geq$ 81 mm		< 81 mm
	All lobster	All	Less berried females	
State	0.689	0.227	0.215	0.462
Cape Ann	0.225	0.169	0.167	0.056
Beverly-Salem	1.024	0.316	0.312	0.707
Cape Cod Bay	0.872	0.268	0.256	0.604
Outer Cape Cod	0.157	0.129	0.118	0.028
Buzzards Bay	0.917	0.204	0.184	0.713

Table 2. Catch per trap-haul per set-over-day by month, regions combined, for all American lobster, and legal (≥ 81 mm) and sub-legal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Month	All lobster	≥ 81 mm	< 81 mm
May	0.626	0.206	0.420
June	0.535	0.144	0.391
July	0.658	0.269	0.389
August	0.542	0.213	0.329
September	1.338	0.392	0.946
October	1.123	0.315	0.808
November	0.567	0.208	0.360

Table 3. Catch per trap-haul per set-over-day by region and month for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Region	May	June	July	August	September	October	November
Cape Ann				0.225			
Beverly-Salem	0.956	0.903					1.172
Cape Cod Bay	0.814	0.407	0.758	1.359	1.338	1.123	0.792
Outer Cape Cod	0.149	0.142	0.314	0.172			0.088
Buzzards Bay	1.172	1.507		0.769			0.580

Table 4. Catch per trap-haul per set-over-day by region and month for legal (≥ 81 mm) and sublegal (< 81 mm) length categories of American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

≥ 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				0.169			
Beverly-Salem	0.233	0.220					0.458
Cape Cod Bay	0.300	0.107	0.292	0.341	0.392	0.315	0.266
Outer Cape Cod	0.132	0.136	0.190	0.140			0.086
Buzzards Bay	0.212	0.292		0.213			0.158

< 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				0.056			
Beverly-Salem	0.723	0.683					0.715
Cape Cod Bay	0.514	0.300	0.467	0.993	0.946	0.808	0.526
Outer Cape Cod	0.017	0.009	0.123	0.032			0.002
Buzzards Bay	0.960	1.215		0.556			0.421

Table 5. Carapace length (mm) by state and region for all American lobster, and legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

		$\geq$ 81 mm		< 81 mm
	All lobster	All	Less berried females	
State	80.4	88.9	88.6	76.2
Cape Ann	86.2	88.9	88.6	78.0
Beverly-Salem	78.7	87.5	87.5	74.7
Cape Cod Bay	80.0	87.7	87.5	76.6
Outer Cape Cod	94.7	98.8	97.8	75.9
Buzzards Bay	77.6	84.8	84.8	75.6

Table 6. Carapace length (mm) by state and region of all male and female American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

	Males	Females
State	80.8	80.1
Cape Ann	88.1	84.8
Beverly-Salem	79.1	78.4
Cape Cod Bay	80.6	79.6
Outer Cape Cod	93.0	96.1
Buzzards Bay	77.9	77.4

Table 7. Carapace length (mm) by month, regions combined, for all American lobster, and legal (≥ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Month	All Lobster	> 81 mm	< 81 mm
May	80.0	89.1	75.4
June	79.3	89.3	75.7
July	80.9	88.0	75.9
August	82.2	90.5	76.8
September	80.2	89.0	76.6
October	79.8	88.1	76.6
November	80.6	88.1	76.3

Table 8. Carapace length (mm) by region and month for all American lobster sampled during commercial lobster trap catch survey, Massachusetts Coastal waters, 1981.

Region	May	June	July	August	September	October	November
Cape Ann				86.2			
Beverly-Salem	77.4	76.4					80.9
Cape Cod Bay	80.7	79.4	80.0	79.6	80.2	79.8	80.3
Outer Cape Cod	93.8	100.8	88.1	96.2			98.5
Buzzards Bay	76.9	77.8		79.1			77.6

Table 9. Carapace length (mm) by region and month for legal (≥ 81 mm) and sublegal (< 81 mm) length categories of American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

≥ 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				88.9			
Beverly-Salem	88.1	88.0					87.0
Cape Cod Bay	86.7	87.4	86.4	87.5	89.0	88.1	87.0
Outer Cape Cod	95.9	102.5	96.4	100.9			98.9
Buzzards Bay	85.2	84.8		84.1			84.7

< 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				78.0			
Beverly-Salem	73.9	72.6					77.0
Cape Cod Bay	77.1	76.6	76.0	76.7	76.6	76.6	76.8
Outer Cape Cod	77.8	75.2	75.3	75.7			80.0
Buzzards Bay	75.1	76.1		77.2			74.9

Table 10. Percent of females ovigerous by state and region for all American lobster, and legal (≥ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

	All lobster	≥ 81 mm	< 81 mm
State	5.8	9.6	4.2
Cape Ann	1.7	2.5	0.0
Beverly-Salem	1.8	2.6	1.5
Cape Cod Bay	3.8	8.2	2.1
Outer Cape Cod	12.4	14.6	0.0
Buzzards Bay	16.6	21.7	15.3

Table 11. Percent of females ovigerous by month, regions combined, for all American lobster, and legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Month	All lobster	$\geq$ 81 mm	< 81 mm
May	9.4	10.0	9.1
June	7.4	15.4	4.8
July	2.6	6.4	0.5
August	5.0	9.8	2.0
September	2.6	6.1	1.2
October	4.8	11.4	2.2
November	9.0	9.2	8.9

Table 12. Percent of females ovigerous by region and month for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Region	May	June	July	August	September	October	November
Cape Ann				1.7			
Beverly-Salem	4.2	0.0					0.9
Cape Cod Bay	3.4	10.4	1.6	1.8	2.6	4.8	2.8
Outer Cape Cod	3.6	11.5	12.3	24.3			3.9
Buzzards Bay	25.4	4.7		6.6			27.1

Table 13. Percent of females ovigerous by region and month for legal (≥ 81 mm) and sublegal (< 81 mm) length categories of American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

≥ 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				2.5			
Beverly-Salem	8.6	0.0					0.0
Cape Cod Bay	6.0	23.7	3.7	4.7	6.1	11.4	3.2
Outer Cape Cod	4.0	12.0	19.6	28.4			4.0
Buzzards Bay	46.4	1.5		0.0			41.9

< 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				0.0			
Beverly-Salem	2.6	0.0					1.5
Cape Cod Bay	1.9	5.8	0.6	0.9	1.2	2.2	2.5
Outer Cape Cod	0.0	0.0	0.0	0.0			0.0
Buzzards Bay	22.6	5.4		10.6			22.7

Table 14. Percent of ovigerous female American lobster within legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories, by state and region, commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

	$\geq$ 81 mm	< 81 mm
State	50.6	49.4
Cape Ann	100.0	0.0
Beverly-Salem	42.9	57.1
Cape Cod Bay	61.5	38.5
Outer Cape Cod	100.0	0.0
Buzzards Bay	25.7	74.3

Table 15. Carapace length (mm) of ovigerous female American lobster by state and region for all lobster, and legal ($\geq$ 81 mm) and sub-legal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

	All Lobster		$\geq$ 81 mm		< 81 mm	
State	85.9	(429)*	94.5	(217)	77.0	(212)
Cape Ann	109.0	(2)	109.0	(2)	-	(0)
Beverly-Salem	82.3	(14)	83.3	(6)	77.0	(8)
Cape Cod Bay	86.7	(192)	92.4	(118)	77.5	(74)
Outer Cape Cod	109.7	(46)	109.7	(46)	-	(0)
Buzzards Bay	78.7	(175)	84.4	(45)	76.7	(130)

* (N)

Table 16. Sex ratios (males to females, expressed in percent) by state and region for all American lobster, and legal (≥ 81 mm) and sub-legal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

	All lobster	≥ 81 mm	< 81 mm
State	41/59	44/56	39/61
Cape Ann	42/58	47/53	24/76
Beverly-Salem	44/56	47/53	43/57
Cape Cod Bay	39/61	44/56	37/63
Outer Cape Cod	44/56	42/58	52/48
Buzzards Bay	43/57	50/50	41/59

Table 17. Sex ratios (males to females, expressed in percent) by month, regions combined, for all American lobster, and legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Month	All lobster	$\geq$ 81 mm	< 81 mm
May	40/60	42/58	39/61
June	41/59	46/54	39/61
July	43/57	51/49	37/63
August	41/59	43/58	39/61
September	40/60	44/56	38/62
October	39/61	40/60	39/61
November	41/59	44/56	40/60

Table 18. Sex ratios (males to females, expressed in percent) by region and month for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Region	May	June	July	August	September	October	November
Cape Ann				42/58			
Beverly-Salem	32/68	55/45					45/55
Cape Cod Bay	37/63	34/66	42/58	42/58	40/60	39/61	38/62
Outer Cape Cod	44/56	45/55	49/51	35/65			49/51
Buzzards Bay	48/52	42/58		39/61			41/59

Table 19. Sex ratios (males to females, expressed in percent) by region and month for legal (≥ 81 mm) and sublegal (< 81 mm) length categories of American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

≥ 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				47/53			
Beverly-Salem	26/74	74/26					44/56
Cape Cod Bay	39/61	35/65	52/48	50/50	44/56	40/60	39/61
Outer Cape Cod	42/58	43/57	47/53	32/68			49/51
Buzzards Bay	67/33	49/51		17/83			52/48

< 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				24/76			
Beverly-Salem	34/66	49/51					45/55
Cape Cod Bay	36/64	33/67	36/64	39/61	38/62	39/61	37/63
Outer Cape Cod	53/47	67/33	52/48	50/50			50/50
Buzzards Bay	44/56	41/59		47/53			38/62

Table 20. Percent recently molted by state and region for all American lobster, and legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

	All lobster	$\geq$ 81 mm	< 81 mm
State	2.5	3.4	2.0
Cape Ann	2.5	3.3	0.0
Beverly-Salem	1.5	2.8	0.9
Cape Cod Bay	0.4	0.5	0.3
Outer Cape Cod	0.8	0.7	0.9
Buzzards Bay	13.1	24.9	9.7

Table 21. Percent recently molted by month, regions combined, for all American lobster, and legal (≥ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, in Massachusetts coastal waters, 1981.

Month	All lobster	≥ 81 mm	< 81 mm
May	0.2	0.2	0.2
June	3.9	6.1	3.1
July	1.2	2.0	0.6
August	1.6	2.6	1.0
September	0.3	0.3	0.3
October	0.3	0.3	0.3
November	8.3	9.7	7.5

Table 22. Percent recently molted by region and month for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Region	May	June	July	August	September	October	November
Cape Ann				2.5			
Beverly-Salem	0.3	4.8					0.3
Cape Cod Bay	0.2	0.4	1.1	0.1	0.3	0.3	0.4
Outer Cape Cod	0.7	0.0	1.9	0.6			0.0
Buzzards Bay	0.0	9.4		9.8			29.2

Table 23. Percent recently molted by region and month for legal ($\geq$ 81 mm) and sublegal ($<$ 81 mm) length categories of American lobster sampled during commercial lobster trap survey, Massachusetts coastal waters, 1981.

$\geq$ 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				3.3			
Beverly-Salem	0.0	12.1					0.4
Cape Cod Bay	0.0	0.0	2.0	0.4	0.3	0.3	0.0
Outer Cape Cod	0.8	0.0	2.1	0.8			0.0
Buzzards Bay	0.0	18.8		16.7			46.4

$<$ 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				0.0			
Beverly-Salem	0.3	2.5					0.3
Cape Cod Bay	0.3	0.5	0.5	0.0	0.3	0.3	0.6
Outer Cape Cod	0.0	0.0	1.6	0.0			0.0
Buzzards Bay	0.0	7.1		7.2			22.8

Table 24. Cull rate by state and region for all American lobster, and legal (≥ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

		≥ 81 mm		< 81 mm
	All lobster	All	Less berried females	
State	11.3	9.3	9.3	12.3
Cape Ann	10.0	10.7	10.8	8.0
Beverly-Salem	7.8	4.0	4.1	9.5
Cape Cod Bay	11.6	9.6	9.6	12.5
Outer Cape Cod	5.6	5.2	5.4	7.7
Buzzards Bay	14.6	16.9	17.9	14.0

Table 25. Cull rate by month, regions combined, for all American lobster, and legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Month	All lobster	$\geq$ 81 mm	< 81 mm
May	8.2	8.0	8.3
June	15.1	12.9	15.9
July	11.4	8.6	13.3
August	10.4	8.4	11.8
September	12.1	9.9	13.1
October	11.5	8.4	12.8
November	8.9	8.2	9.3

Table 26. Cull rate by region and month for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Region	May	June	July	August	September	October	November
Cape Ann				10.0			
Beverly-Salem	4.9	15.1					5.6
Cape Cod Bay	7.7	13.7	12.0	11.3	12.1	11.5	9.5
Outer Cape Cod	5.4	6.3	6.3	6.3			3.0
Buzzards Bay	12.5	18.9		9.8			12.8

Table 27. Cull rate by region and month for legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories of American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

$\geq$ 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				10.7			
Beverly-Salem	4.2	6.6					2.9
Cape Cod Bay	5.2	15.0	9.3	7.8	9.9	8.4	11.0
Outer Cape Cod	6.2	5.6	5.2	5.4			3.1
Buzzards Bay	21.4	18.0		12.5			15.0

< 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				8.0			
Beverly-Salem	5.1	17.0					7.2
Cape Cod Bay	9.2	13.2	13.7	12.6	13.1	12.8	8.8
Outer Cape Cod	0.0	16.7	8.1	10.0			0.0
Buzzards Bay	10.5	19.2		8.8			12.0

Table 28. Shell disease incidence (% individuals) by state and region for all American lobster, and legal (≥ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

	All lobster	≥ 81 mm	< 81 mm
State	0.15	0.17	0.14
Cape Ann	0.50	0.67	0.00
Beverly-Salem	0.22	0.00	0.32
Cape Cod Bay	0.13	0.12	0.14
Outer Cape Cod	0.45	0.37	0.85
Buzzards Bay	0.54	0.24	0.00

Table 29. Shell disease incidence (% individuals) by month, region combined, for all American lobster, and legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Month	All lobster	$\geq$ 81 mm	< 81 mm
May	0.20	0.00	0.29
June	0.14	0.35	0.06
July	0.00	0.00	0.00
August	0.13	0.34	0.00
September	0.38	0.43	0.36
October	0.07	0.00	0.10
November	0.05	0.00	0.08

Table 30. Shell disease incidence (% individuals) by region and month for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Region	May	June	July	August	September	October	November
Cape Ann				0.50			
Beverly-Salem	0.51	0.00					0.16
Cape Cod Bay	0.00	0.10	0.00	0.00	0.38	0.07	0.00
Outer Cape Cod	0.68	2.08	0.00	0.00			0.00
Buzzards Bay	0.00	0.00		0.58			0.00

Table 31. Shell disease incidence (% individuals) by region and month for legal (≥ 81 mm) and sublegal (< 81 mm) length categories of American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

≥ 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				0.67			
Beverly-Salem	0.00	0.00					0.00
Cape Cod Bay	0.00	0.00	0.00	0.00	0.43	0.00	0.00
Outer Cape Cod	0.00	2.22	0.00	0.00			0.00
Buzzards Bay	0.00	0.00		2.08			0.00

< 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				0.00			
Beverly-Salem	0.68	0.00					0.27
Cape Cod Bay	0.00	0.13	0.00	0.00	0.36	0.10	0.00
Outer Cape Cod	5.88	0.00	0.00	0.00			0.00
Buzzards Bay	0.00	0.00		0.00			0.00

Table 32. Trap mortality (% individuals) by state and region for all American lobster, and legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

	All lobster	$\geq$ 81 mm	< 81 mm
State	0.09	0.07	0.10
Cape Ann	0.00	0.00	0.00
Beverly-Salem	0.00	0.00	0.00
Cape Cod Bay	0.00	0.00	0.00
Outer Cape Cod	0.46	0.85	0.37
Buzzards Bay	0.43	0.48	0.24

Table 33. Trap mortality (% individuals) by month, regions combined, for all American lobster, and legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Month	All lobster	$\geq$ 81 mm	< 81 mm
May	0.07	0.00	0.10
June	0.23	0.00	0.32
July	0.00	0.00	0.00
August	0.27	0.34	0.22
September	0.00	0.00	0.00
October	0.00	0.00	0.00
November	0.05	0.13	0.00

Table 34. Trap mortality (% individuals) by region and month for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

Region	May	June	July	August	September	October	November
Cape Ann				0.00			
Beverly-Salem	0.00	0.00					0.00
Cape Cod Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outer Cape Cod	0.68	0.00	0.00	0.63			1.00
Buzzards Bay	0.00	0.76		1.73			0.00

Table 35. Trap mortality (% individuals) by region and month for legal ($\geq$ 81 mm) and sublegal (< 81 mm) length categories of American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981.

$\geq$ 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				0.00			
Beverly-Salem	0.00	0.00					0.00
Cape Cod Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outer Cape Cod	0.00	0.00	0.00	0.78			1.02
Buzzards Bay	0.00	0.00		2.08			0.00

< 81 mm

Region	May	June	July	August	September	October	November
Cape Ann				0.00			
Beverly-Salem	0.00	0.00					0.00
Cape Cod Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outer Cape Cod	5.88	0.00	0.00	0.00			1.02
Buzzards Bay	0.00	0.94		1.60			0.00

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